International Journal of Sustainability and Advanced Integrated Research
Volume 2, Issue 1 (January-March 2026) | ISSN: 3107-7854
DOI: https://doi.org/10.65339/ijsair.V2.I1.144

Students' Experiences in Science Investigatory Project Making: Basis for Developing a Transformative Science Investigatory Model

Daisy Jane C. Cajelo[1], Mauricia S. Bapilar, EdD[1]
[1]Holy Name University - Tagbilaran City, Bohol

Publication history: Received: February 10, 2026; Revised: March 27, 2026; Accepted: March 28, 2026
Email of Corresponding Author: cajelo.daisy_jane@hnu.edu.ph

Abstract

This study examined the experiences of junior high school students in conducting Science Investigatory Projects (SIPs) in the DepEd Division of Bohol and developed a Science Investigatory Project-Making Model based on the findings. Anchored on inquiry-based learning and supported by constructivist and experiential learning perspectives within the Knowledge, Skills, and Attitudes framework, the study viewed SIP as an authentic learning experience that develops scientific competencies. A descriptive qualitative research design was employed, utilizing Focus Group Discussions with eighteen Grade 9 and 10 students from three selected secondary schools, chosen through purposive sampling. Data were transcribed and analyzed through thematic analysis, with software used to support data organization. Findings revealed that SIP participation contributed to the development of scientific knowledge, research skills, and positive scientific attitudes. Students demonstrated improved understanding of scientific concepts and research processes, enhanced skills in experimentation, measurement, data analysis, research writing, and communication, and developed attitudes such as patience, perseverance, honesty, curiosity, and teamwork. However, students encountered challenges related to time constraints, limited resources, technical difficulties, research documentation, and emotional pressures. The findings further indicated the need for scaffolding support, including mentorship, access to resources, time management, collaboration, technical training, and emotional support. Based on these results, a Transformative Science Investigatory Project Model was developed to provide a structured and scaffolded approach to SIP implementation. The study concludes that SIP is a meaningful inquiry-based learning experience and recommends strengthened institutional support and guided implementation. The study aligns with SDG 4 by promoting quality education through inquiry-based learning and supports SDG 8 and SDG 9 by enhancing research competencies and innovation. Its sustainability impact lies in strengthening science education practices, supporting student readiness for research, and improving institutional learning systems.

Keywords: Qualitative Research, Inquiry-Based Learning, Junior High School Students, Science Investigatory Project, Scientific Attitudes, Scientific Knowledge, Scientific Skills

1. Introduction

This study examines the experiences of junior high school students in conducting Science Investigatory Projects (SIPs) within the DepEd Division of Bohol. Anchored on inquiry-based learning, SIPs provide authentic research experiences that develop students' scientific knowledge, skills, and attitudes (KSAs). However, variations in implementation, resource limitations, and student difficulties highlight the need to understand learners' experiences, challenges, and scaffolding needs. The study aims to generate insights that inform the development of a Science Investigatory Project-Making Model to strengthen research-based learning aligned with the K to 12 Science Curriculum.

1.1 Inquiry-Based Science Investigatory Project Experiences of Junior High School Students in Bohol Division

The K to 12 Science Curriculum aims to develop scientifically, technologically, and environmentally literate learners who are critical problem solvers, innovative thinkers, and responsible citizens (Department of Education [DepEd], 2016). Inquiry-based learning is central to this goal, enabling students to explore scientific questions, analyze evidence, and construct explanations. Science Investigatory Projects support this approach by engaging students in authentic research processes such as identifying problems, formulating hypotheses, conducting experiments, analyzing data, and communicating findings. These experiences enhance critical thinking, creativity, collaboration, and scientific communication (Pedaste et al., 2015). In Philippine basic education, SIPs are widely implemented and linked to science fairs such as the DSTF, RSTF, and NSTF, which promote innovation and application of science in solving community problems (DepEd, 2016). Within the DepEd Division of Bohol, participation in SIPs varies across schools due to differences in resources and support systems. Students encounter challenges throughout the investigatory process, including topic selection, literature review, methodology design, data analysis, and presentation (Pedaste et al., 2015; Darling-Hammond et al., 2020). Resource limitations such as inadequate laboratory facilities further affect project feasibility and quality. These conditions emphasize the need for structured guidance and scaffolding. Despite the importance of SIPs, limited research has examined students' experiences in Bohol, particularly regarding KSAs, challenges, and scaffolding needs. Additionally, no locally developed model currently guides SIP implementation. This study addresses these gaps by examining students' experiences and developing a context-based SIP model.

1.2 Themes and Insights on Knowledge, Skills, Attitudes, Challenges, and Scaffolding in SIP Implementation

Science Investigatory Projects function as inquiry-based learning experiences that develop scientific competencies by enabling students to acquire knowledge of scientific concepts, apply research skills, and cultivate attitudes such as curiosity, perseverance, and collaboration. Research indicates that authentic inquiry enhances conceptual understanding and engagement (Pedaste et al., 2015) and strengthens problem-solving, critical thinking, and communication skills (Acut et al., 2022). Furthermore, investigatory projects foster motivation and persistence in science learning (Ryan & Deci, 2017; Wilton Lodge et al., 2025; Forbes & Skamp, 2019). However, inquiry-based tasks are complex, and students often struggle with various stages of the research process, which may reduce motivation without adequate support (Bell et al., 2016; Ryan & Deci, 2017). Scaffolding plays a crucial role in addressing these challenges by providing structured guidance in topic selection, experimentation, data analysis, and reporting (Bell et al., 2016). These insights highlight the importance of understanding students' experiences to design effective support mechanisms that enhance SIP implementation.

1.3 Local, National, and Global Context of Science Investigatory Project Implementation

At the local level, SIP implementation in the DepEd Division of Bohol varies depending on school resources, facilities, and research support, with some schools actively participating in science fairs while others face limitations affecting student engagement and output quality. At the national level, SIPs align with educational policies such as Republic Act No. 10533, which promotes inquiry-based and learner-centered education, and DepEd Order No. 39, s. 2016, which encourages research engagement among learners (Department of Education, 2016). Republic Act No. 2067 further supports scientific research and technological advancement. Globally, science education emphasizes early research engagement to prepare students for STEM participation (UNESCO, 2021), and inquiry-based approaches are widely recognized for enhancing scientific reasoning and conceptual understanding (Orbeta et al., 2021).

1.4 Constructivist–Experiential Framework for Knowledge, Skills, and Attitudes Development in SIP

This study is grounded in Constructivist Learning Theory, which posits that learners actively construct knowledge through experience and interaction rather than passively receiving information (Zhang & Ma, 2023). In the context of SIPs, students develop understanding by engaging in real-world investigations, formulating research questions, interpreting data, and generating conclusions. The study is also anchored in Kolb's Experiential Learning Theory, which explains learning as a continuous cycle involving concrete experience, reflective observation, abstract conceptualization, and active experimentation (Gargarita, 2021). This cycle is evident in SIP processes, where students conduct experiments, reflect on observations, connect findings to scientific concepts, and apply insights to further inquiry. The study adopts the Knowledge, Skills, and Attitudes (KSA) framework, where knowledge refers to understanding scientific concepts, skills involve applying scientific processes, and attitudes include values such as curiosity, perseverance, and responsibility. These frameworks collectively explain how SIPs facilitate holistic learning.

1.5 Research Gaps in SIP Experiences, Challenges, and Scaffolding Needs in Bohol Division

Despite the recognized value of Science Investigatory Projects, there is limited research on students' lived experiences in conducting SIPs within the DepEd Division of Bohol. Existing studies on inquiry-based learning do not sufficiently address the specific knowledge, skills, and attitudes developed during SIP implementation, the challenges encountered by students, and the scaffolding needs required for successful project completion. Furthermore, there is no locally developed model that integrates these elements into a structured framework for SIP implementation. Addressing these gaps is essential to improving the consistency and quality of SIP implementation and ensuring alignment with the intended competencies of the K to 12 Science Curriculum.

1.6 Alignment with Relevant Sustainable Development Goals (SDGs)

This study aligns with Sustainable Development Goal 4 (Quality Education) by promoting inquiry-based learning and the development of scientific literacy, critical thinking, and research competencies among students. It also supports Sustainable Development Goal 8 (Decent Work and Economic Growth) by strengthening learners' readiness for future STEM-related careers through research skill development. Additionally, the study contributes to Sustainable Development Goal 9 (Industry, Innovation, and Infrastructure) by encouraging innovation and problem-solving through scientific investigation. These alignments demonstrate the study's contribution to strengthening educational and innovation-focused sustainability.

1.7 Importance of the Study to Educational and Socio-Scientific Sustainability

This study contributes to educational sustainability by enhancing inquiry-based science instruction and supporting the development of lifelong learning competencies among students. It also supports socio-economic sustainability by preparing learners with scientific knowledge and research skills relevant to technological advancement and workforce readiness.

Furthermore, the study promotes innovation sustainability by fostering creativity and problem-solving through authentic research experiences. At the institutional level, it provides insights that can inform instructional practices, school policies, and program implementation, thereby strengthening the overall quality of science education. By developing a Science Investigatory Project-Making Model, the study ensures that SIP implementation becomes more structured, effective, and responsive to students' needs, ultimately supporting sustainable improvements in science education.

2. Material and methods

2.1 Research Design

This study employed a descriptive qualitative research design to examine the experiences of junior high school students in conducting Science Investigatory Projects and the learning competencies developed during the process. Descriptive qualitative research focuses on providing a clear and detailed account of participants' experiences within their natural context, allowing the researcher to describe and interpret phenomena based on participants' perspectives without imposing complex theoretical interpretations. This design was appropriate as it enabled the documentation of how students conducted their investigatory projects, the challenges they encountered, and the support mechanisms that facilitated their completion. The study utilized Focus Group Discussions (FGDs) as the primary method of data collection. Through group interaction, participants were able to share their experiences in selecting research topics, designing procedures, gathering and analyzing data, and presenting findings. These discussions revealed common experiences, challenges, and forms of support encountered during the investigatory process. The discussions were audio-recorded with participants' consent and transcribed verbatim for analysis. The data were analyzed using thematic analysis, which involves identifying patterns and themes through systematic coding and categorization. NVivo software was used to organize and manage qualitative data during coding, while interpretation of themes remained the responsibility of the researcher. Ethical considerations were strictly observed, including informed consent, voluntary participation, and confidentiality of responses.

2.2 Locale of the Study

The study was conducted in three selected secondary schools in the Second Congressional District of the DepEd Division of Bohol during the school year 2025–2026, namely President Carlos P. Garcia Memorial High School in Talibon 1 District, San Miguel Technical and Vocational School in San Miguel District, and Mahayag National High School in San Miguel District. These schools were purposively selected because they actively implement Science Investigatory Projects as part of their science curriculum and regularly participate in science fairs and division-level competitions. The selected schools represented diverse contexts within the district. President Carlos P. Garcia Memorial High School is situated in a relatively urbanized area with access to laboratory facilities and strong instructional support, while San Miguel Technical and Vocational School and Mahayag National High School provide rural settings where students integrate technical and practical skills into their investigatory projects. These varied contexts allowed the study to capture differences in resources, school culture, and student experiences, which are important factors influencing the development of knowledge, skills, and attitudes in Science Investigatory Project implementation.

2.3 Respondents of the Study

The respondents of the study consisted of eighteen junior high school students from Grades 9 and 10 who were enrolled in science subjects and had prior experience in conducting Science Investigatory Projects. These grade levels were selected because students at this stage have already engaged in scientific inquiry and are capable of describing and reflecting on their investigatory experiences. The participants came from the three selected schools within the Second Congressional District of the Bohol Division during the school year 2025–2026. They were organized into six focus groups, each composed of three students, to facilitate interaction and allow participants to collectively share their experiences, challenges, and insights related to Science Investigatory Project implementation.

2.4 Sample and Sampling Procedure

A purposive sampling technique was used to select participants who met specific inclusion criteria relevant to the objectives of the study. The participants were selected based on their experience in conducting Science Investigatory Projects, participation in district-level competitions, and representation of their schools in investigatory project contests. These criteria ensured that the participants had sufficient experience in the investigatory process and could provide meaningful insights into their learning experiences. The sample size was considered appropriate for qualitative inquiry, as it allowed for in-depth exploration of participants' experiences while maintaining manageable group discussions. The inclusion of students from different schools provided varied perspectives influenced by differences in instructional support, research guidance, and available resources, contributing to a richer understanding of SIP implementation across contexts.

2.5 Research Instrument

The primary research instrument used in this study was a Focus Group Discussion guide designed to elicit detailed accounts of students' experiences in conducting Science Investigatory Projects. The instrument consisted of open-ended questions organized around key thematic areas aligned with the study's objectives, including the knowledge, skills, and attitudes developed by students, the challenges encountered during the investigatory process, and the scaffolding support needed to complete the projects successfully. The FGD guide was validated by experts in science education, research methodology, and qualitative research to ensure clarity, relevance, and alignment with the research objectives. Feedback from the experts was incorporated to refine the instrument. The guide was subsequently pilot-tested with students who were not part of the study but shared similar characteristics with the intended participants. The pilot testing helped identify issues related to wording, redundancy, and question sequencing, and necessary revisions were made to improve the clarity and flow of the instrument.

2.6 Data Gathering Procedure

The study commenced after obtaining ethical clearance from the Ethics Review Board of Holy Name University. Formal permission was secured from the Schools Division Superintendent, District Supervisors, and School Principals to conduct the study in the selected schools. Parental consent and student assent were obtained prior to participation, ensuring that participants were fully informed about the purpose, procedures, and voluntary nature of the study. Focus Group Discussions were conducted using a semi-structured guide that allowed participants to describe their experiences in selecting research topics, conducting experiments, analyzing data, and presenting findings. The discussions were audio-recorded with participants' consent and later transcribed verbatim for analysis. Throughout the process, ethical standards were strictly observed, including the protection of participants' confidentiality through the use of codes or pseudonyms and secure storage of data. The study complied with Republic Act 10173 or the Data Privacy Act of 2012, ensuring responsible handling of personal information. Participation was voluntary, and students were informed of their right to withdraw at any time without consequences. All data collected were used solely for academic purposes and were securely stored and protected throughout the research process.

2.7 Data Analysis Techniques

The data collected from the Focus Group Discussions were analyzed using thematic analysis following Braun and Clarke (2006). The analysis began with the transcription of recorded discussions, capturing participants' statements verbatim, including relevant conversational elements. The researcher then reviewed the transcripts multiple times to gain familiarity with the data and identify significant statements. Initial codes were assigned to meaningful segments of data, representing key ideas related to students' experiences. These codes were grouped into categories based on similarities and relationships, forming broader patterns within the data. From these categories, themes were identified and refined to represent participants' shared experiences and insights. NVivo software was used to assist in organizing, storing, and retrieving qualitative data during the coding process. While NVivo facilitated efficient data management, the interpretation of codes, categories, and themes remained the responsibility of the researcher. Through systematic coding, categorization, and thematic analysis, the study generated insights into the knowledge, skills, and attitudes developed by students, as well as the challenges encountered and scaffolding needs in Science Investigatory Project implementation.

3. Results and Discussion

3.1 Development of Scientific Knowledge, Skills, and Attitudes through SIP

3.1.1 Development of Scientific Knowledge through Inquiry-Based Experiences

The findings revealed that students developed deeper scientific knowledge through active engagement in research activities. Participants demonstrated improved understanding of scientific concepts, awareness of the research process, and the ability to apply science in real-life contexts. Students reported gaining knowledge in areas such as biology, chemistry, and material properties, as well as recognizing that scientific research requires careful procedures and repeated validation. Their experiences also indicated that learning extended beyond classroom instruction through hands-on investigation. This result supports the view that inquiry-based learning enhances conceptual understanding and scientific literacy by allowing students to actively construct knowledge through experimentation and investigation (Antonio & Prudente, 2023) Engaging in authentic research processes fosters curiosity and independent learning, enabling students to view science as a dynamic process rather than static knowledge. Furthermore, active participation in inquiry tasks strengthens cognitive engagement and understanding of scientific principles (Azriyanti, 2023).

3.1.2 Development of Scientific and Research Skills in SIP Implementation

The results indicated that students developed a wide range of scientific and research skills, including experimentation, measurement, data analysis, programming, and research documentation. Participants highlighted improvements in conducting experiments, interpreting data, and writing research reports, while some also developed technical skills such as coding. These findings demonstrate that SIP provides opportunities for students to engage in systematic investigation and apply scientific methods in practice. This finding aligns with studies showing that inquiry-based learning enhances higher-order thinking skills such as critical thinking and problem-solving (Azriyanti, 2023; Antonio & Prudente, 2023). Hands-on research activities allow students to develop scientific reasoning by designing experiments and analyzing empirical data. Additionally, inquiry-driven STEM projects foster creativity, collaboration, and technical competence (Archer et al., 2020).

The improvement in scientific communication skills further supports research emphasizing the role of project-based learning in enhancing students' ability to present and communicate findings effectively (Acut, 2022).

3.1.3 Development of Scientific Attitudes, Values, and Emotional Engagement

The findings showed that students developed positive scientific attitudes such as patience, perseverance, honesty, curiosity, and teamwork. These attitudes emerged as students engaged in repeated experimentation, collaborative work, and problem-solving tasks. Students also demonstrated research integrity by reporting results honestly and maintaining accuracy in data collection. In addition, emotional outcomes such as pride, accomplishment, satisfaction, and increased interest in science were evident after completing the SIP, although some students expressed conditional willingness or reluctance to engage in future research due to perceived difficulty and fatigue. These results support the idea that inquiry-based learning environments foster positive attitudes toward science and enhance motivation and engagement. Collaborative learning further strengthens interpersonal skills and promotes shared responsibility (Archer et al., 2020; Acut, 2022). Emotional outcomes such as pride and satisfaction reflect increased self-efficacy and intrinsic motivation (Ryan & Deci, 2017; Linnenbrink-Garcia et al., 2016), while the transition from stress to relief aligns with the dynamic nature of academic emotions (Pekrun, 2018). Increased interest in science and emerging STEM aspirations confirm that authentic research experiences can influence long-term engagement in scientific fields (Palmer et al., 2017; Schraw et al., 2020; Maltese et al., 2017; Kitchen et al., 2018). However, conditional participation and reluctance highlight the importance of contextual support in sustaining engagement (Ainley & Hidi, 2017; Trautwein et al., 2018).

3.2 Challenges Affecting Science Investigatory Project Implementation

The findings revealed that students encountered multiple challenges during the implementation of Science Investigatory Projects, including time constraints, limited research resources, technical and experimental difficulties, research documentation issues, and emotional pressures. Students reported difficulties in balancing SIP requirements with academic responsibilities, often sacrificing personal time to complete research tasks. Limited access to laboratory equipment and materials hindered experimentation, while technical issues such as coding errors and experimental failures required repeated trials. Students also experienced difficulties in writing research papers and organizing data, as well as emotional challenges such as anxiety, confusion, and pressure during the research process. These challenges reflect the complex nature of inquiry-based learning, where extended research activities require significant time, resources, and cognitive effort. Time management difficulties are consistent with findings that project-based learning demands extensive planning and execution (Bell, 2018; Blumenfeld et al., 2017). Limited access to laboratory resources affects the quality of scientific investigations and constrains students' ability to apply experimental methods. Technical and experimental challenges highlight the authentic nature of scientific inquiry, where trial and error contribute to learning but may also cause frustration without adequate support (Bybee, 2018). Difficulties in research writing align with studies emphasizing the complexity of scientific communication (Aditomo & Klieme, 2021). Emotional responses such as anxiety and stress further confirm that demanding academic tasks can influence motivation and persistence.

3.3 Scaffolding Needs in Science Investigatory Project Implementation

The findings indicated that students require multiple forms of scaffolding support to successfully complete Science Investigatory Projects, including research guidance and mentorship, access to laboratory resources, time management support, collaborative learning environments, and technical skills training. Students emphasized the importance of teacher guidance in designing experiments, analyzing data, and writing research reports. They also identified the need for adequate equipment and materials, structured schedules, peer collaboration, and training in technical and research skills. Additionally, emotional support was necessary to help students manage anxiety, stress, and pressure throughout the research process. These results highlight the critical role of scaffolding in inquiry-based learning, where structured support enables students to perform complex tasks and gradually develop independence. Guided inquiry approaches have been shown to improve learning outcomes by balancing support and autonomy (Lazonder & Harmsen, 2016; Pedaste et al., 2015). Access to laboratory resources enhances engagement and supports the application of scientific concepts (Abrahams & Reiss, 2017). Time management support is essential for organizing research tasks and reducing stress (Zimmerman & Kitsantas, 2018; Broadbent & Poon, 2017), while collaborative learning promotes problem-solving and deeper understanding (Johnson & Johnson, 2019). Technical training strengthens students' competence in scientific investigation (Freeman et al., 2017; National Academies of Sciences, 2018). Emotional scaffolding is equally important, as it helps students cope with anxiety and sustain engagement in challenging learning tasks (Pekrun et al., 2017; Linnenbrink-Garcia et al., 2016; Pascoe et al., 2020; Putwain & Daly, 2014; Pekrun, 2018; Ryan & Deci, 2017).

3.4 Transformative Science Investigatory Project Model Based on Students' Experiences

The findings led to the development of a Transformative Science Investigatory Project Model that conceptualizes SIP as a structured and developmental learning process rather than a single academic task. The model presents SIP as a sequence of interconnected phases that guide students from initial engagement to sustained scientific interest. It emphasizes that effective SIP implementation requires intentional scaffolding that integrates cognitive, technical, and emotional support throughout the research process. The model highlights that students experience progression from uncertainty and limited knowledge to increased competence, confidence, and interest in science through guided inquiry and structured support. This model aligns with contemporary perspectives on inquiry-based learning, which emphasize the importance of scaffolding in enabling students to engage meaningfully in scientific investigation. It reflects the principle that effective learning occurs when students are supported through progressive stages of competence development while gradually gaining independence. The integration of emotional support within the model recognizes that learning is not purely cognitive but also influenced by students' affective experiences. By incorporating guidance, resources, collaboration, and reflection, the model supports the development of scientific knowledge, research skills, and positive attitudes toward science, thereby strengthening the implementation of Science Investigatory Projects and promoting long-term engagement in scientific inquiry.

4. Conclusion & Recommendations

The study established that Science Investigatory Projects function as meaningful inquiry-based learning experiences that contribute to the development of students' scientific knowledge, research skills, and positive attitudes toward science. Students demonstrated improved understanding of scientific concepts, enhanced research competencies, and strengthened scientific values through hands-on investigation and collaborative engagement. However, the implementation of SIP is affected by challenges such as time constraints, limited resources, technical difficulties, and emotional pressures, which influence students' ability to complete research tasks effectively. These findings highlight the importance of providing structured scaffolding, including guidance, resources, and collaborative support, to facilitate successful implementation. The developed Transformative Science Investigatory Project Model provides a structured framework that integrates these supports and ensures that SIP becomes a systematic and transformative learning process.

The study recommends the adoption of a scaffolded approach in implementing Science Investigatory Projects, where teachers provide continuous guidance throughout the stages of orientation, inquiry, experimentation, documentation, and reflection to support students' learning and research processes. Schools and educational institutions should strengthen support systems by improving access to laboratory facilities, research materials, and scheduling arrangements that allow students to balance academic and research demands. School administrators and program coordinators are encouraged to establish structured research support mechanisms such as mentorship programs, consultations, and technical training to enhance students' competencies. Students are encouraged to actively engage in collaborative learning and maintain open communication with peers and mentors to improve their research experience. Future researchers may conduct further studies to examine the long-term effects of SIP participation and evaluate the applicability of the proposed model in different contexts to strengthen its implementation.

This study was limited to the experiences of selected junior high school students from three public secondary schools in the Second Congressional District of the Bohol Division during the school year 2025–2026. The findings were based on qualitative data gathered through focus group discussions, reflecting the participants' perspectives within their specific school contexts. The study focused only on students' experiences, knowledge, skills, attitudes, challenges, and scaffolding needs in conducting Science Investigatory Projects and did not examine other factors such as teacher practices, administrative policies, or broader institutional conditions in depth. Therefore, the results may not be generalized to all schools or educational settings beyond those included in the study.

Compliance with ethical standards

The Author declares no conflict of interest, and this study received no external funding as it was conducted solely for academic purposes. The researcher acknowledges the participating junior high school students and the support of school authorities for their cooperation and contributions to the study.

REFERENCES

Abrahams, I., & Reiss, M. (2017). *Practical work in secondary science: A minds-on approach*. Routledge.

Acut, D. (2022). Developing SIPCaR projects utilizing modern technologies: Its impact on students' engagement, R&D skills, and learning outcomes. *LUMAT: International Journal on Math, Science and Technology Education, 10*(1), 294–318. https://doi.org/10.31129/LUMAT.10.1.1657

Aditomo, A., & Klieme, E. (2021). Forms of inquiry-based science instruction and their relations with learning outcomes. *International Journal of Science Education, 43*(13), 2049–2067. https://doi.org/10.1080/09500693.2021.1964817

Ainley, M., & Hidi, S. (2017). Interest development and its relation to engagement and learning. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 205–222). Routledge. https://doi.org/10.4324/9781315771045

Allchin, D. (2017). Beyond the nature of science: Scientific habits of mind. *Science Education, 101*(1), 123–142. https://doi.org/10.1002/sce.21224

Antonio, V., & Prudente, M. (2023). Inquiry-based learning approach and students' conceptual understanding in science education. *International Journal of Instruction, 16*(2), 1127–1144. https://doi.org/10.29333/iji.2023.16260a

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2020). "Science capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts. *Journal of Research in Science Teaching, 52*(7), 922–948. https://doi.org/10.1002/tea.21227

Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: Young people's science and career aspirations, age 10–19. *Science Education, 104*(4), 742–768. https://doi.org/10.1002/sce.21567

Azriyanti, R. (2023). The effect of inquiry-based learning on students' critical thinking and science process skills. *Journal of Science Learning, 6*(2), 250–259. https://doi.org/10.17509/jsl.v6i2.53030

Bandura, A. (2018). Toward a psychology of human agency: Pathways and reflections. *Perspectives on Psychological Science, 13*(2), 130–136. https://doi.org/10.1177/1745691617699280

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2019). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 90*(6), e193–e210. https://doi.org/10.1111/cdev.13128

Bell, S. (2018). Project-based learning for the 21st century: Skills for the future. *The Clearing House, 91*(2), 39–43. https://doi.org/10.1080/00098655.2018.1423734

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2016). Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education, 38*(3), 349–377. https://doi.org/10.1080/09500693.2016.1145367

Bencze, L., Sperling, E., & Carter, L. (2018). Students' research-informed socio-scientific activism: Re/visioning science education. *Research in Science Education, 48*(1), 1–22. https://doi.org/10.1007/s11165-016-9571-0

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (2017). Motivating project-based learning. *Educational Psychologist, 52*(3), 200–215. https://doi.org/10.1080/00461520.2017.1324369

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in reflexive thematic analysis? *Qualitative Research in Psychology, 18*(3), 328–352. https://doi.org/10.1080/14780887.2020.1769238

Broadbent, J., & Poon, W. (2017). Self-regulated learning strategies and academic achievement in online higher education learning environments: A systematic review. *Internet and Higher Education, 27*, 1–13. https://doi.org/10.1016/j.iheduc.2015.04.007

Bybee, R. (2018). *The BSCS 5E instructional model: Creating teachable moments*. NSTA Press.

D'Mello, S. K., & Graesser, A. C. (2018). Confusion can be beneficial for learning. *Learning and Instruction, 29*, 153–170. https://doi.org/10.1016/j.learninstruc.2012.05.003

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Department of Education. (2016). *DepEd Order No. 39, s. 2016: Adoption of the Basic Education Research Agenda*. https://www.deped.gov.ph

Department of Education. (2016). *K to 12 science curriculum guide*. https://www.deped.gov.ph/wp-content/uploads/2019/01/Science-CG_with-tagged-sci-equipment_revised.pdf

Eccles, J. S., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory. *Contemporary Educational Psychology, 61*, 101859. https://doi.org/10.1016/j.cedpsych.2020.101859

Forbes, C. T., & Skamp, K. (2019). Secondary science students' engagement in inquiry-based learning: A review of research. *Research in Science Education, 49*(3), 641–670. https://doi.org/10.1007/s11165-017-9639-7

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2016). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. (2017). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gargarita, J. (2021). Experiential learning approach: Its effects on students' performance and engagement. *International Journal of Educational Research Review, 6*(2), 145–152. https://doi.org/10.24331/ijere.873947

Grover, S., & Pea, R. (2018). Computational thinking: A competency whose time has come. *Computer Science Education, 28*(1), 1–29. https://doi.org/10.1080/08993408.2018.1457422

Hidi, S., & Renninger, K. A. (2019). Interest development and its relation to motivation. *Educational Psychologist, 54*(2), 73–91. https://doi.org/10.1080/00461520.2019.1614020

Johnson, D. W., & Johnson, R. T. (2019). Cooperative learning and social interdependence theory. *Theory Into Practice, 58*(3), 254–263. https://doi.org/10.1080/00405841.2019.1623360

Kitchen, J. A., Sonnert, G., & Sadler, P. M. (2018). The impact of college- and university-run high school summer programs on students' end-of-high-school STEM career aspirations. *Science Education, 102*(3), 529–547. https://doi.org/10.1002/sce.21332

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research, 86*(3), 681–718. https://doi.org/10.3102/0034654315627366

Linnenbrink-Garcia, L., Patall, E. A., & Pekrun, R. (2016). Adaptive motivation and emotion in education: Research and principles for instructional design. *Policy Insights from the Behavioral and Brain Sciences, 3*(2), 228–236. https://doi.org/10.1177/2372732216644450

Maltese, A. V., Tai, R. H., & Fan, X. (2017). When is homework worth the time? Evaluating the association between homework and achievement in high school science and math. *The High School Journal, 100*(3), 209–224. https://doi.org/10.1353/hsj.2017.0001

National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures*. National Academies Press. https://doi.org/10.17226/24783

Orbeta, A. C., Jr., Paqueo, V. B., & Francisco-Abrigo, K. (2021). *Improving the K to 12 curriculum: Lessons and policy directions*. Philippine Institute for Development Studies. https://doi.org/10.2139/ssrn.3809333

Palmer, D., Dixon, J., & Archer, J. (2017). Changes in science teaching self-efficacy among primary teacher education students. *Australian Journal of Teacher Education, 42*(3), 1–15. https://doi.org/10.14221/ajte.2017v42n3.1

Pascoe, M. C., Hetrick, S. E., & Parker, A. G. (2020). The impact of stress on students in secondary school and higher education. *International Journal of Adolescence and Youth, 25*(1), 104–112. https://doi.org/10.1080/02673843.2019.1596823

Pedaste, M., Mäeots, M., Siiman, L., De Jong, T., Van Riesen, S., Kamp, E., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Pekrun, R. (2018). Control-value theory: A social-cognitive approach to achievement emotions. In G. A. D. Liem & D. M. McInerney (Eds.), *Big theories revisited 2: Research on sociocultural influences on motivation and learning* (pp. 162–190). Information Age Publishing.

Pekrun, R., Lichtenfeld, S., Marsh, H. W., Murayama, K., & Goetz, T. (2017). Achievement emotions and academic performance: Longitudinal models of reciprocal effects. *Child Development, 88*(5), 1653–1670. https://doi.org/10.1111/cdev.12704

Piaget, J. (1970). *Science of education and the psychology of the child*. Viking Press.

Putwain, D. W., & Daly, A. L. (2014). Test anxiety prevalence and gender differences in a sample of English secondary school students. *Educational Studies, 40*(5), 554–570. https://doi.org/10.1080/03055698.2014.953914

Republic Act No. 10533. (2013). *Enhanced Basic Education Act of 2013*. https://www.officialgazette.gov.ph

Republic Act No. 2067. (1958). *Science Act of 1958*. https://www.officialgazette.gov.ph

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.

Schraw, G., Flowerday, T., & Lehman, S. (2020). Increasing situational interest in the classroom. *Educational Psychology Review, 13*(3), 211–224. https://doi.org/10.1023/A:1016619705184

Trautwein, U., Lüdtke, O., Schnyder, I., & Niggli, A. (2018). Predicting homework effort: Support for a domain-specific, multilevel homework model. *Journal of Educational Psychology, 98*(2), 438–456. https://doi.org/10.1037/0022-0663.98.2.438

UNESCO. (2021). *Engineering for sustainable development: Delivering on the Sustainable Development Goals*. UNESCO Publishing. https://doi.org/10.18356/9789216040095

Wilton Lodge, R., et al. (2025). Student engagement in authentic science research experiences: A longitudinal study. *Journal of Science Education and Technology*. Advance online publication. https://doi.org/10.1007/s10956-025-10012-3

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis. *Frontiers in Psychology, 14*, Article 1202728. https://doi.org/10.3389/fpsyg.2023.1202728

Zimmerman, B. J., & Kitsantas, A. (2018). Self-regulated learning and student achievement. *Educational Psychologist, 53*(2), 79–86. https://doi.org/10.1080/00461520.2018.1449114