International Journal of Science, Technology and Interdisciplinary Practices

ORIGINAL RESEARCH | e-Published: January 18, 2026 *Open Access*

Vol. 2, No. 1 (2026). pp. 23-40 DOI: 10.69481/XCBP5102

Predictors of Research Self-Efficacy of STEM Graduates in a Science Investigatory Project Class: Toward a Research Self-Efficacy Promotion Model

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Abstract

This study determined the predictors of research self-efficacy among STEM graduates in a science investigatory project class and examined the levels at which these predictors occur, their influence on STEM graduates' research self-efficacy, to develop a model for facilitating research self-efficacy. Utilizing a descriptive-correlational research design, the study employed Partial Least Squares - Structural Equation Modeling (PLS-SEM) with 241 STEM graduates of Surigao del Norte National High School who responded to adapted and researcher-made survey questionnaires via Google Forms. The findings revealed that the highest level of research self-efficacy was in Research Ethics and Integrity (M=3.55), while the lowest was in Data Analysis (M=3.38). Regarding the extent of factors that predict research self-efficacy, Research Mentoring Experience recorded the highest mean (M=3.63), while Research Training Environment scored the lowest (M=3.31). Significant intercorrelations were observed between all factors of research self-efficacy, with correlation coefficients ranging from moderate to weak ($r = 0.16$ to 0.78). Crucially, although the level of research self-efficacy in science investigatory project were all positively correlated with all the factors that predict research self-efficacy, multiple linear regression analysis only identified Investigative Interest ($\beta=0.41$, $p<0.001$) and Research Training Environment ($\beta=0.12$, $p=0.019$) as the only significant predictors of research self-efficacy, while Research Anxiety, Working Alliance, and Research Mentoring Experience were non-significant predictors. Further, this was translated to the findings of the structural equation modeling and validated Investigative Interest and Research Training Environment as the only factors that significantly and positively influence research self-efficacy. The study contributes to the SIRSE (Social Cognitive Processes, Investigative Interest, Research Training Environment, Self-Efficacy) Model, providing an empirically derived research self-efficacy model mediated by Social Cognitive Theory. Thus, the study recommends the implementation of hands-on data analysis workshops and establishing a dedicated research budget to provide students with research materials. Ultimately, the adoption of the SIRSE Model is proposed to systematically recalibrate DepEd's research curriculum for fostering confident researchers.

Keywords: Predictors, Research Self-Efficacy, STEM Graduates, PLS-SEM, Science Investigatory Project, SIRSE Model

1. Introduction

The quest for scientific knowledge takes a systematic, objective form, conducted through intensive, careful, empirical research that leads to the development of generalizations, principles, and theories that provide information to solve problems. Research is characterized by a rigorous set of principles and guidelines for procedures governed by the scientific method, and these aspects of research are important for students, specifically Science, Technology, Engineering, and Mathematics (STEM) students, to be equipped with the necessary knowledge, values, and skills throughout the research process. Generally, the nature and objectives of scientific research involve carefully planning and conducting experiments on a particular topic and gathering empirical evidence to understand a phenomenon better. However, it is also important to consider the factors that make students confident and successful in their scientific research. This tenet, called "research self-efficacy," is underappreciated and less conspicuous among STEM students, as we mainly focus on their scientific and research skills.

Self-efficacy is the person's belief in their capacities and executing that capacity to achieve a particular goal (Bandura, 1977; Bandura, 1986; Bandura, 1997). This belief in their capacity to work plays a pivotal role for every individual, as it influences a person's behavior, motivation, and process across aspects of human life. Self-efficacy boosts a person's drive to learn and do the unimaginable, overcoming the limitless boundaries set by society. As mentioned by Pajares (2019), learning would be well served by paying as much attention to students' perceptions of competence as to the actual competence, for it is the perceptions that may more accurately predict students' motivation and future academic choices. Hence, when students express their confidence in learning and exhibit self-efficacy, they are more likely to become competent and confident learners who see problems as challenges, are committed to learning, and can overcome failure.

In the context of research, particularly in scientific investigative projects, research self-efficacy also plays an important role in fostering scientific research skills by cultivating a culture of confidence in their abilities to find meaningful solutions to their research problems (Hu, Jiang, and Bi, 2022). In a science investigatory project, students are not only tasked with developing prototypes or models to solve real-world problems, but also with coping with setbacks when the prototypes and models do not go as planned. To overcome this, students must possess high levels of self-efficacy to bounce back from failure and confidently continue to master their skills, as mastery of experience is correlated with their interpretations of previous performance (Bandura, 1997, 2012; Britner & Pajares, 2006; Kiran & Sungur, 2012).

On the other hand, global data suggests that Filipino students ranked lowest among countries in terms of research skills (Maggioncalda, 2024). This should not be confused with the recent ranking of the Philippines in the Program for International Student Assessment (PISA), where, out of 64 countries, the Philippines ranked in the bottom four (Organization for Economic Cooperation and Development, 2024). As a result, students have a hard time identifying their research problem, devising a research plan, collecting and analyzing data, presenting the results in tabular and parenthetical format, and defending their research study, leading to poor performance in research skills.

Moreover, in our ASEAN neighbors, the Philippines also lagged Malaysia, Thailand, and Singapore in research productivity (Guido and Orleans, 2020). These results are so problematic, as they generally show that Filipinos' standing in research competency and productivity is not in line with global standards. This results in a growing number of Filipino graduates who are unable to conduct basic research, such as problem identification, literature review, selection of research methodology, data collection and analysis, and the like.

Lastly, at the national level, significantly lower research competency data were found among Filipino graduates, indicating that the country is missing the point in addressing the root cause of the underperformance of Filipino student researchers today (Ng, 2025). Additionally, Lauengco (2026) said that, apart from poor basic research skills, there is a critical decline in the scientific research skills of Filipino students, wherein the vast majority struggle to write, interpret, or apply scientific concepts in science investigatory projects.

In Surigao del Norte, teachers frequently report that senior high school students exhibit significant gaps in fundamental research competencies, particularly in the science investigatory project (SIP). These gaps manifest as they struggle to independently formulate hypotheses, identify experimental variables, and accurately interpret complex data, which are skills that are the bedrock of rigorous scientific research. Research in Surigao del Norte, as mentioned by Llano et al. (2023), supported these observations, and they inferred that these gaps are often the result of systemic problems, including a lack of hands-on laboratory experience and inconsistent exposure to inquiry-based learning during the foundational school years. Hence, students graduate from senior high school with little to no knowledge of writing a scientific research paper and are unable to introspect how well and confidently they write science investigatory projects.

Consequently, several studies have already been conducted on students' research skills, self-efficacy, and skill development, as well as the factors that influence students' research self-efficacy. For example, the research by Poh and Abdullah (2019) enumerated factors influencing students' research self-efficacy and identified the research training environment, research interest, and research mentoring as key factors. However, the study involved PhD students in the applied arts department and identified only a few factors that significantly and positively influence students' research self-efficacy. In addition, Rimban (2025) conducted a systematic review of the impact of research self-efficacy on students' academic success. The author identified several factors that influence students' research self-efficacy, including mentoring quality, research training environments, research activity engagement, and year of study. However, there is a clear gap in methodology: the study conducted only a systematic review of factors that influence students' research self-efficacy across various studies, rather than explicitly measuring how these factors significantly and positively influence students' research self-efficacy.

Given these persisting global, national, and local issues, there is a significant research gap in understanding how research self-efficacy can guide STEM graduates to become confident and competent researchers, as well as how it enables them to reflect on how well and confidently, they write scientific research papers. While various studies have addressed these issues independently, there has been little research into identifying the factors that influence STEM graduates' research self-efficacy and to what extent do these factors predict their research self-efficacy. Addressing this gap is critical to ensure that STEM students will graduate with the necessary knowledge and skills in science investigatory project as well as ensure that students are confident and well-prepared in university for advanced scientific research writing.

Theoretical Framework

This study was anchored on Bandura's Social Cognitive Theory, particularly the concept of self-efficacy. Bandura (1977, 1986, 1997) explained that self-efficacy refers to a person's belief in his or her capability to organize and perform actions needed to achieve a desired outcome. In this study, self-efficacy was applied to the research context. It referred to the confidence of STEM graduates in performing the major tasks required in a science investigatory project, such as identifying a research problem, reviewing literature, developing theoretical and conceptual frameworks, formulating research questions, selecting research designs, analyzing data, interpreting findings, and observing research ethics.

Aim of the Study

In light of these concerns, this research aims to determine the level of STEM graduates' research self-efficacy and the extent to which factors predict it. In doing so, the study goes beyond measuring actual research performance to measuring students' perceived capability (self-efficacy) in conducting a science investigatory project. Pinpointing these predictive factors allows the study to shed new light on them and to provide a comprehensive model for promoting research self-efficacy.

Research Questions

This study determined the predictors of research self-efficacy of STEM graduates in science investigatory project and to what extent do these factors influence their research self-efficacy to generate a model for a comprehensive research self-efficacy. Specifically, this study sought to answer the following questions:

1. What is the level of STEM graduates' research self-efficacy in science investigatory project in terms of:
    1.1. Research Problem Identification;
    1.2. Literature Review;

1.3. Theoretical & Conceptual Framework;
1.4. Research Question Formulation;
1.5. Research Design and Methodology;
1.6. Data Analysis;
1.7. Interpretation and Reporting; and
1.8. Research Ethics and Integrity?

2. To what extent do the following factors predict STEM graduates' research self-efficacy:
   2.1. Research Anxiety;
   2.2. Investigative Interests;
   2.3. Research Training Environment;
   2.4. Working Alliance; and
   2.5. Research Mentoring Experience?
3. Is there a significant correlation between the level of STEM graduates' research self-efficacy and the factors that predict STEM graduates' research self-efficacy?
4. To what extent do the factors predict STEM graduates' research self-efficacy?
5. Which of the following factors significantly influence STEM graduates' research self-efficacy when analyzed using PLS-SEM?
6. Based on the results, what model on promoting research self-efficacy can be developed?

Hypotheses Development

Null Hypothesis
At 0.05 level of significance, it was hypothesized that:
H_{o1}: There is no significant correlation between the level of STEM graduates' research self-efficacy and the factors that predict STEM graduates' research self-efficacy.
H_{o2}: Research Anxiety, Investigative Interests, Research Training Environment, Working Alliance, and Research Mentoring Experience do not significantly predict STEM graduates' research self-efficacy.

Hypotheses for Structural Equation Modeling

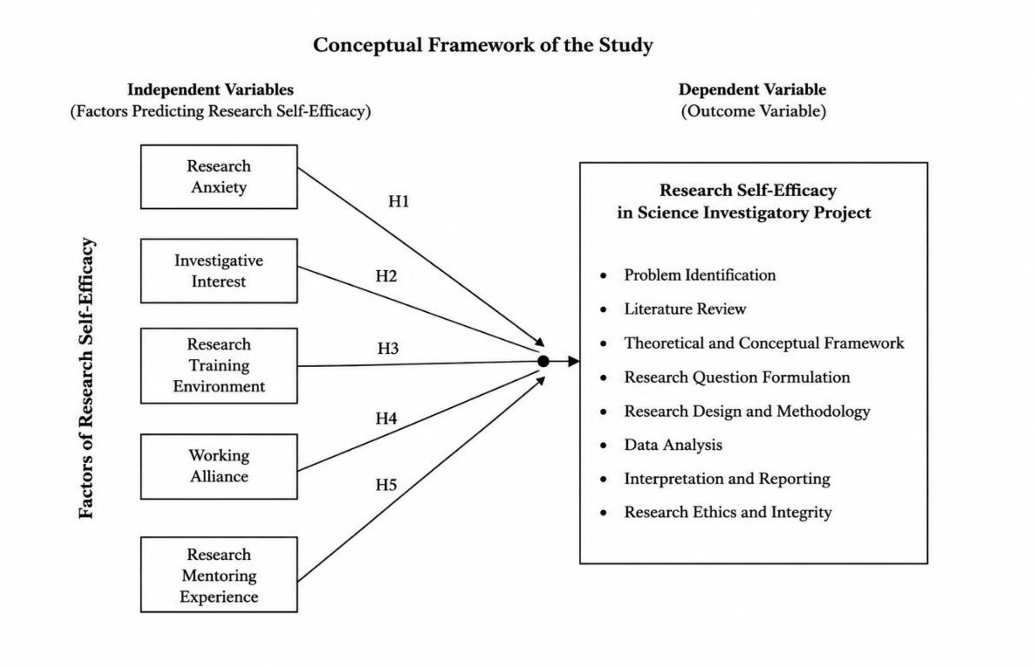

Figure 1. Hypothesized Structural Equation Model on STEM Graduates' Research Self-Efficacy

In this hypothesized model, five (5) distinct factors are proposed to independently influence STEM graduates' research self-efficacy in science investigatory project. Each of these factors plays a direct role in shaping how students perceive their ability to successfully engage in science investigatory project, without interacting with or depending on one another. The model suggests that each of these factors contributes independently to significant and positively influence STEM graduates' research self-efficacy in science investigatory project.

Consequently, these factors were hypothesized as follows:
H1: Research Anxiety significantly and positively influence STEM graduates' Research Self-Efficacy.
H2: Investigative Interests significantly and positively influence STEM graduates' Research Self-Efficacy.
H3: Research Training Environment significantly and positively influence STEM graduates' Research Self-Efficacy.
H4: Working Alliance significantly and positively influence STEM graduates' Research Self-Efficacy.
H5: Research Mentoring Experience significantly and positively influence STEM graduates' Research Self-Efficacy.

2. Literature Review

The Philippine education system aims to produce scientifically literate and research-capable graduates through the K to 12 curriculum. In the Senior High School STEM strand, students are expected to undertake science investigatory projects as a core academic requirement. These projects require students to identify problems, formulate hypotheses, design procedures, gather data, analyze findings, and communicate results. Although previous studies have examined self-efficacy in STEM learning, particularly in relation to mastery experiences, vicarious learning, and affective development, limited evidence has explained how several factors collectively predict the research self-efficacy of STEM graduates in the Philippine context.

Research self-efficacy refers to students' belief in their ability to perform research tasks with confidence. Udem and Anaehobi (2020) noted that research self-efficacy is associated with students' interest in conducting research, including science investigatory projects. Low research self-efficacy may reduce students' willingness to engage in research tasks. In contrast, students with higher research self-efficacy are more likely to complete research activities effectively and contribute to research productivity. This suggests that research competence is not shaped only by technical skill. It is also influenced by students' confidence in their role as student-researchers. This confidence is linked to the affective domain of learning. Ocak and Ataseven (2016) explained that the affective domain supports the research process because it influences information literacy, inquiry behavior, and problem-solving skills. Thus, science investigatory projects develop not only students' higher-order psychomotor and cognitive skills but also their research confidence.

Although many studies on self-efficacy have been published, limited research has focused specifically on the research self-efficacy of Filipino STEM students. Existing Philippine studies have mostly examined research confidence and research engagement in broader educational contexts. Rahon et al. (2021), for instance, examined the influence of the K to 12 curriculum on the self-efficacy of Filipino researchers and affirmed the continuing relevance of Bandura's concept of self-efficacy in determining whether learners believe they can perform a given task. This concern is important because Filipino students have been reported to experience low motivation and limited confidence in research writing. Similar observations were reported by Camara (2020), Dela Cruz (2019), and Paurillo (2019), who found issues related to learning engagement, research writing ability, and participation in research defense among Filipino learners.

The reviewed studies reveal a clear gap in both context and method. They did not fully capture the research self-efficacy of Filipino STEM graduates in relation to science investigatory projects. There is still limited baseline evidence on how students perceive their capability across the major stages of conducting scientific research. This gap is important because scientific inquiry requires curiosity, creativity, problem-solving, and confidence. In a developing country such as the Philippines, students must be prepared not only to complete school-based research requirements but also to conduct scientific work that can address practical problems. Hence, examining the predictors of research self-efficacy among STEM graduates is necessary to understand how they develop confidence in conducting science investigatory projects.

3. Methodology

Research Design

This study used a quantitative research approach with a descriptive-correlational research design. The descriptive component was used to determine the level of research self-efficacy of STEM graduates in science investigatory projects. It also described the extent of the five predictor variables, namely Research Anxiety, Investigative Interest, Research Training Environment, Working Alliance, and Research Mentoring Experience. The correlational component was used to examine the relationships between these predictors and the eight dimensions of research self-efficacy.

The study also employed Partial Least Squares–Structural Equation Modeling (PLS-SEM) to test the proposed predictive model. This technique was appropriate because research self-efficacy was treated as a multidimensional construct composed of several research-related competencies. PLS-SEM allowed the study to examine the direct influence of the predictor variables on research self-efficacy while also assessing the strength of the proposed model.

Before the PLS-SEM analysis was conducted, multiple linear regression was first used to identify which factors significantly predicted research self-efficacy. The significant predictors were then examined further through PLS-SEM to validate the structural relationships among the constructs. Thus, the use of descriptive statistics, correlation, regression, and PLS-SEM provided a more systematic analysis of the factors that influenced STEM graduates' research self-efficacy in science investigatory projects.

Participants / Data Sources

The respondents of this study were the 241 STEM graduates of Surigao del Norte National High School, Schools Division of Surigao del Norte, last School Years 2022-2025. These respondents were selected based on purposive sampling technique as this allows for the deliberate selection of respondents who possess specific characteristics essential to answering the research question.

To establish clarity, this study assumed that the research self-efficacy developed by 241 STEM graduates do not change over time nor does fluctuate whether they are a fresh graduate from School Year 2024-2025 or from School Year 2022-2023. This dissertation strongly adhered to the idea that research self-efficacy shows high normative stability during educational transition. This basically means that even though STEM graduates might learn new knowledge and skills as a fresh graduate or as a junior college student conducing basic research, their perceived level of confidence in conducting science investigatory project or any research projects stays pretty much the same as what they built up during their senior high school years (Datu and Mateo; Robnett et al., 2015).

Furthermore, this study assumed that all respondents have received similar exposure to co-curricular research activities, such as seminars on conducting science investigatory projects, training on Arduino development, application of Internet of Things (IoT), robotics manipulation, and laboratory experimentation. These assumptions of common SIP-based experience allow the study to focus on the constructs of research self-efficacy and the factors that predict their research self-efficacy since all STEM graduates had the same characteristics. Hence, the study does not have to account for the demographic profile, which was deliberately excluded from this study.

Instruments

The study used two survey instruments. The first was an adapted questionnaire used to measure the level of research self-efficacy of STEM graduates. The second was a researcher-made questionnaire used to measure the extent of the factors that predict research self-efficacy.

Part I of the instrument was adapted from the Comprehensive Research Self-Efficacy Scale developed by Tas et al. (2023). The original scale consisted of 28 indicators designed to measure research self-efficacy. Since the original instrument did not explicitly classify the indicators into named dimensions, the researcher reorganized the items based on the literature on research self-efficacy and the major stages of conducting a science investigatory project. The items were grouped into eight dimensions: research problem identification, literature review, theoretical and conceptual framework, research question formulation, research design and methodology, data analysis, interpretation and reporting, and research ethics and integrity. Since the number of indicators was uneven across the eight dimensions, additional items were developed so that each dimension would contain five indicators. This process followed recommended practices in scale development, where sufficient item representation is needed for each construct (Boateng et al., 2018).

Part II of the instrument was a researcher-made questionnaire developed to measure the extent of the factors predicting research self-efficacy. The constructs were based on the meta-analysis of Livinti et al. (2021), which identified key factors associated with research self-efficacy. These factors were Research Anxiety, Investigative Interest, Research Training Environment, Working Alliance, and Research Mentoring Experience. Since the meta-analysis identified the factors but did not provide specific measurable indicators for each construct, the researcher developed original items for the questionnaire. Following the scale development guidance of Boateng et al. (2018), five indicators were prepared for each construct, resulting in 25 items for this part of the instrument.

The items for Research Anxiety were written in a negative form to capture feelings of fear, worry, and stress experienced during the conduct of a science investigatory project. The items for Investigative Interest, Research Training Environment, Working Alliance, and Research Mentoring Experience were written in a neutral-positive form to measure the extent to which these factors supported the development of research self-efficacy among STEM graduates.

Data Analysis

Data were analyzed using Mean and Standard Deviation to determine the levels of STEM graduates' research self-efficacy and as well as the extent of the factors that predict their research self-efficacy. Pearson-r to determine the relationship between the level of research self-efficacy and extent of the factors that predict their research self-efficacy. Multiple Regression Analysis to determine which of the five (5) factors are significant predictors of STEM graduates' research self-efficacy. Partial Least Squares - Structural Equation Modelling (PLS-SEM) to test the model and produce a structural model with parameter estimates based on the study's findings. This was used as a complementary statistical tool wherein multiple linear regression was used for preliminary identification of predictors, while PLS-SEM was employed for confirmatory modeling and structural validation.

4. Results / Findings

Table 1. Level of STEM Graduates' Research Self-Efficacy in Science Investigatory Project

Constructs	M	SD	VR	QD
Research Problem Identification	3.46	0.586	Strongly Agee	Highly Confident
Literature Review	3.40	0.652	Strongly Agee	Highly Confident
Theoretical and Conceptual Framework	3.41	0.646	Strongly Agee	Highly Confident
Research Question Formulation	3.42	0.633	Strongly Agee	Highly Confident
Research Design and Methodology	3.49	0.596	Strongly Agee	Highly Confident
Data Analysis	3.38	0.682	Strongly Agee	Highly Confident
Interpretation and Reporting	3.52	0.598	Strongly Agee	Highly Confident
Research Ethics and Integrity	3.55	0.593	Strongly Agee	Highly Confident
Overall Response	**3.45**	**0.623**	**Strongly Agee**	**Highly Confident**

Legend: 3.26-4.00 (Strongly Agree/Highly Confident); 2.51-3.25 (Moderately Agree/Moderately Confident); 1.76-2.50 (Slightly Agree/Slightly Confident); 1.00-1.75 (Disagree/Not Confident)

As shown in Table 1, Research Ethics and Integrity obtained the highest mean (M = 3.55, SD = 0.593). This indicates that STEM graduates were highly confident in observing ethical standards, maintaining research integrity, addressing authorship and conflict of interest concerns, protecting participants, and complying with school ethics guidelines. This finding supports Lasco et al. (2021), Sales et al. (2025), and Limson et al.

(2023), who emphasized that ethical research training strengthens students' confidence in performing research tasks responsibly.

Data Analysis obtained the lowest mean (M = 3.38, SD = 0.682), although it was still interpreted as Highly Confident. This suggests that STEM graduates believed they could analyze data, but this area remained the weakest among the research self-efficacy dimensions. Newell and Ulrich (2022) and Lachance et al. (2020) noted that hands-on data analysis experience can improve research confidence and help students interpret findings more effectively.

STEM graduates showed a high level of research self-efficacy in science investigatory projects (M = 3.45, SD = 0.623). They were most confident in research ethics and integrity, but they still needed stronger support and training in data analysis.

Table 2. Extent of the Factors Predicting STEM Graduates' Research Self-Efficacy in Science Investigatory Project

Constructs	M	SD	VR	QD
Research Anxiety	3.37	0.758	Always	High Extent
Investigative Interests	3.37	0.698	Always	High Extent
Research Training Environment	3.31	0.774	Always	High Extent
Working Alliance	3.61	0.618	Always	High Extent
Research Mentoring Experience	3.63	0.616	Always	High Extent
Overall Response	**3.46**	**0.693**	**Always**	**High Extent**

Legend: 3.26-4.00 (Always/High Extent); 2.51-3.25 (Often/Moderate Extent); 1.76-2.50 (Rarely/Less Extent); 1.00-1.75 (Never/No Extent)

Table 2 shows that Research Mentoring Experience obtained the highest mean (M = 3.63, SD = 0.616). This indicates that STEM graduates often received guidance, encouragement, and support from their research advisers. Mentoring helped strengthen their confidence in conducting science investigatory projects. This finding supports Cutillas et al. (2023), who found that mentoring positively affects students' research skills, especially when psychosocial support and career-related guidance are provided.

Research Training Environment obtained the lowest mean (M = 3.31, SD = 0.774), although it was still interpreted as High Extent. This suggests that students experienced limitations in laboratory equipment, research facilities, funding, materials, logistical support, and training in the use of research tools. This finding supports Osaiyuwu (2025), who noted that adequate laboratory facilities improve students' academic performance, research skills, and confidence in science-related tasks.

Overall, mentoring was the most evident support received by STEM graduates, while the research training environment remained the weakest area. This implies that schools should sustain research mentoring while improving facilities, equipment, materials, and institutional support for science investigatory projects.

Table 3. Significant Correlation Between the Level of STEM Graduates' Research Self-Efficacy and Extent of the Factors Predicting Research Self-Efficacy

	RPI	LR	TCF	RQF	RDM	DA	IR	REI	RA	II	RTE	WA	RME
RPI													
LR	0.75												
TCF	0.69	0.69											
RQF	0.71	0.68	0.70										
RDM	0.67	0.68	0.66	0.73									
DA	0.72	0.69	0.69	0.69	0.78								
IR	0.66	0.62	0.67	0.66	0.65	0.69							
REI	0.58	0.52	0.60	0.58	0.60	0.61	0.67						
RA	0.25	0.18	0.22	0.22	0.16	0.21	0.19	0.28					
II	0.58	0.56	0.56	0.59	0.61	0.58	0.56	0.50	0.24				
RTE	0.46	0.48	0.54	0.52	0.48	0.50	0.36	0.38	0.23	0.55			
WA	0.35	0.38	0.49	0.46	0.41	0.39	0.35	0.42	0.18	0.44	0.56		
RME	0.28	0.34	0.45	0.38	0.36	0.35	0.30	0.38	0.16	0.37	0.54	0.83	

Note: p <0.001; * p <0.01; ** p <0.05

The Pearson correlation results showed statistically significant relationships among the variables (p < .001). Thus, H_{01} was rejected. The eight dimensions of research self-efficacy showed strong positive intercorrelations (r = .52 to .78), which indicates that these dimensions were closely connected and formed a unified construct of research self-efficacy.

Among the predictor variables, Investigative Interest showed moderate to strong positive correlations with all research self-efficacy domains (r = .50 to .61). This means that students with stronger interest in science investigatory projects tended to report higher confidence in conducting research. This supports the view that investigative interest contributes to academic persistence, research engagement, and research competency (Alcazaren & Robiños, 2022; De Vries et al., 2024).

Research Training Environment and Working Alliance also showed moderate positive correlations with research self-efficacy (r = .35 to .56). This suggests that supportive research environments and collaborative relationships with teachers and peers may help strengthen students' confidence in completing research tasks. This finding aligns with Uy and Callo (2023), who noted that a supportive environment contributes to research readiness and research skills.
Research Anxiety showed weak but significant positive correlations with the research self-efficacy domains (r = .16 to .28). This indicates that anxiety was present but had a weaker association compared with the other predictors. Although research anxiety may affect motivation and confidence, it may also coexist with research engagement when students are properly guided (Zhenlei et al., 2024).

Overall, the findings suggest that investigative interest, research training environment, working alliance, and mentoring were meaningful correlates of research self-efficacy. Research anxiety had only a weak association. Therefore, students' confidence in conducting science investigatory projects appeared to be more strongly linked with interest, support, and learning environment than with anxiety.

Table 4. Model Summary of the Regression Analysis on the Factors that Predict STEM Graduates' Research Self-Efficacy

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.66	0.44	0.40	0.300

The model demonstrated a Moderate Positive Correlation between the level of STEM graduates' research self-efficacy and the factors that predict research self-efficacy as indicated by its R-value (R=0.66). On the other hand, the R^2, which is 0.44, measures the proportion of the variance indicating that approximately 44% of the variance in research self-efficacy is explained by the combined effects of the five predictors. This suggests that the selected factors collectively provide a meaningful explanation of students' research self-efficacy. Further, the adjusted R^2 of 0.40 means 40% of the variance in research self-efficacy among STEM graduates is explained by the factors that influence research self-efficacy after adjusting, which is a more accurate measure of the goodness of fit of the model. Then, 60% of what influences a STEM graduates' research self-efficacy in science investigatory project are attributed to other constructs outside the model.

Furthermore, Table 5 below showed the Regression Model Goodness-of-Fit Using ANOVA to determine whether the predictors identified collectively and meaningfully explain the variance in research self-efficacy among STEM graduates engaged in science investigatory projects.

Table 5. Regression Model Goodness-of-Fit Using ANOVA

Model	Sum of Squares	df	Mean Square	F	p-value
Regression	8.5911	5	8.5911	79.937	<0.001
Residual	25.2562	235	0.1075		

It can be gleaned in Table 5 about the significance of the regression model's goodness of fit using ANOVA. In addition, it is evident that the p-value is <0.001, which was less than the 0.05 level of significance, indicating that the regression model is deemed statistically significant at the 0.05 significance level. This implies that the model is sufficiently robust for calculating which factor significantly predicts STEM graduates' research self-efficacy.

Consequently, it can be gleaned in Table 6 below the Regression Model Estimated Model Coefficient that revealed the unique contribution and specific weight of each predictor constructs of research self-efficacy in predicting STEM graduates' research self-efficacy in conducting science investigatory project.

Table 6. Regression Model Estimated Model Coefficient

Model	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	SE	Beta		
Intercept	1.19	0.21		5.75	<.001
RA	0.03	0.04	0.05	0.73	0.465
II	0.41	0.05	0.53	7.92	<.001
RTE	0.12	0.05	0.07	2.37	0.019
WA	0.14	0.08	0.27	1.72	0.087
RME	-0.03	0.08	-0.12	-0.36	0.722

Model Coefficient: Level of STEM Graduates' Research Self-Efficacy

Research Anxiety was not a significant predictor of research self-efficacy ($\beta = 0.03$, $p = .465$). Thus, H_{02} was not rejected for this variable. This means that anxiety did not directly predict STEM graduates' confidence in conducting science investigatory projects, although it may still be present during research work. This may be because students can manage anxiety through help-seeking, social support, and resilience (Ahmad et al., 2021; Beadel et al., 2016; Richardson, 2023).

Investigative Interest was the strongest significant predictor of research self-efficacy ($\beta = 0.41$, $p < .001$). Thus, H_{02} was rejected for this variable. This indicates that students who showed stronger curiosity, interest, and engagement in scientific inquiry were more confident in conducting research. This supports the view that research interest improves critical thinking, problem-solving, independent learning, and research productivity (Xu, 2023).

Research Training Environment was also a significant predictor of research self-efficacy ($\beta = 0.12$, $p = .019$). Thus, H_{02} was rejected for this variable. This means that access to research facilities, laboratory equipment, institutional support, and learning resources helped strengthen students' confidence in completing science investigatory projects. Well-maintained laboratories and hands-on learning opportunities are important in developing research skills and research confidence (Doncillo & Justo, 2025).

Working Alliance was not a significant predictor of research self-efficacy ($\beta = 0.14$, $p = .087$). Thus, H_{02} was not rejected for this variable. Although the result showed a positive coefficient, it did not independently predict research confidence. However, regular consultation, timely feedback, and collaborative discussion may still help improve students' research engagement and writing competence (Gutierrez et al., 2024).

Research Mentoring Experience was also not a significant predictor of research self-efficacy ($\beta = -0.03$, $p = .722$). Thus, H_{02} was not rejected for this variable. Although mentoring is theoretically linked to research confidence, the result showed that it did not significantly predict research self-efficacy in this study. This finding differed from Savic et al. (2025), who argued that mentoring supports the development of research self-efficacy and research identity.
Overall, only Investigative Interest and Research Training Environment significantly predicted STEM graduates' research self-efficacy. Investigative Interest was the strongest predictor. Research Anxiety, Working Alliance, and Research Mentoring Experience did not significantly predict research self-efficacy.

Structural Equation Model on STEM Graduates' Research Self-Efficacy

The table below showed the results of the structural equation modeling (SEM) for explaining how foundational factors influence students' research self-efficacy. Moreover, utilizing PLS-SEM was a complementary statistical tool for confirmatory modeling and structural validation based on the predicted variables on the results of multiple regression analysis. Moreover, as reflected in Table 7, the overall model fit revealed mixed but acceptable results. The chi-square test was statistically significant, χ^2 = 264.39, $p < 0.001$, indicating some discrepancy between the observed and model covariance matrices.

Table 7. Overall Model Fit of Structural Equation Model

Label	X^2	df	p-value	Remarks	Decision
User Model	264.39	64	<.001	Significant	Accepted
Baseline Model	2256.74	78	<.001	Significant	Accepted

However, given the known sensitivity of chi-square to sample size, additional fit indices were considered, as shown in Table 8. The Comparative Fit Index (CFI = 0.91) and Bollen's Incremental Fit Index (IFI = 0.91) suggest acceptable model fit, while the Tucker-Lewis Index (TLI = 0.89) and Parsimony Normed Fit Index (NFI = 0.89) fall slightly below the recommended threshold. Furthermore, the Root Mean Square Error of Approximation (RMSEA = 0.11, 95% CI [0.10, 0.13]) and Standardized Root Mean Square Residual (SRMR = 0.11) exceed ideal cut-off values, indicating that the model may require refinement. Despite these limitations, the model is sufficiently acceptable for structural equation modeling and theory-building purposes.

Table 8. Additional Fit Indices for Structural Equation Model

Fit Indices	Model	Decision
Comparative Fit Index (CFI)	0.91	Accepted
Tucker-Lewis Index (TLI)	0.89	Accepted
Bollen's Incremental Fit Index (IFI)	0.91	Accepted
Parsimony Normed Fit Index (PNFI)	0.72	Accepted
SRMR	0.11	Accepted
RMSEA	0.11	Accepted

Legend: CFI (Good Fit = >0.95; Acceptable Fit = 0.90 to 0.95); TLI (Good Fit = >0.95; Acceptable Fit = 0.90 to 0.95); IFI (Good Fit = >0.95; Acceptable Fit = >0.90); PNFI (Acceptable Fit = >0.60); SRMR (Good Fit = <0.05); RMSEA (Good Fit = <0.06).

On the other hand, Table 9 showed the measurement model containing the structural model and the beta coefficients path for each latent and observed construct. The measurement model further clarifies the composition of the latent constructs. Factors of Research Self-Efficacy is significantly represented by several indicators, with Investigative Interest (β = .92, $p < 0.001$) and Research Training Environment (β = .88, $p = 0.002$) emerging as the strongest contributors. Hence, this signifies that H2 and H3 are supported, which means that Investigative Interest and Research Training Environment both significantly and positively influence research self-efficacy.

Table 9. Measurement Model on the Factors of Research Self-Efficacy and Level of Research Self-Efficacy in Science Investigatory Project

Latent	Observed	SE	β	p	Remarks
Factors of Research Self-Efficacy	RA	0.00	0.22	0.55	Not Supported
	II	1.09	0.92	<.001	Supported
	RTE	1.00	0.88	0.002	Supported
	WA	0.66	0.52	0.494	Not Supported
	RME	0.89	0.65	0.26	Not Supported
Level of Research Self-Efficacy in Science Investigatory Project	RPI	0.00	0.84	<.001	Supported
	LR	0.07	0.81	<.001	Supported
	TCF	0.07	0.83	<.001	Supported
	RQF	0.07	0.84	<.001	Supported
	RDM	0.07	0.84	<.001	Supported
	DA	0.07	0.86	<.001	Supported
	IR	0.07	0.79	<.001	Supported
	REI	0.07	0.72	<.001	Supported

This was supported by Renninger and Hidi (2022) who said that the presence of interest is an antecedent of motivation and continued learning engagement. They further believed that when students are interested in doing the things they are required to complete, they can cultivate a sense of accomplishment leading to the development of positive self-efficacy. On the other hand, Woo et al. (2024) revealed in their study that research training environment significantly and positively moderates the relationship between research self-efficacy and research productivity of students. In the context of the study, it can be denoted that a conducive research training environment combined with adequate resources and access to physical learning has a direct and positive influence on STEM graduates' ability to develop SIP.

However, Research Mentoring Experience ($\beta = 0.65$, $p = 0.26$) and Working Alliance ($\beta = 0.52$, $p = 0.494$), and Research Anxiety serves as the reference indicator with a comparatively lower loading ($\beta = 0.22$, $p = 0.55$) and non-significant influence towards STEM graduates' research self-efficacy. Hence, this signifies that H1, H3 and H5 are not supported, which means Research Anxiety, Working Alliance, and Research Mentoring Experience do not significantly and positively influence research self-efficacy.

Subsequently, the second latent construct represents the higher-order outcomes of research self-efficacy. This construct is reflected by eight observed domains of science investigatory project namely, Research Problem Identification (RPI), Theoretical and Conceptual Framework (TCF), Literature Review (LR), Research Question Formulation (RQF), Research Design and Methodology (RDM), Data Analysis (DA), Interpretation and Reporting (IR), and Research Ethics and Integrity (REI). All indicators demonstrate statistically significant loadings ($p < .001$), indicating strong measurement validity. Among these indicators, Data Analysis ($\beta = 0.86$), Research Question Formulation ($\beta = 0.84$), Research Project Implementation ($\beta = 0.84$), Research Design and Methodology ($\beta = 0.84$), and Theoretical and Conceptual Framework Development ($\beta = 0.83$) show strong contributions. Literature Review ($\beta = 0.81$) and Interpretation of Results ($\beta = 0.79$) also contribute substantially, while Research Ethics and Integrity ($\beta = 0.72$) demonstrate moderate but still significant loading. These results indicate that advanced research competency is multifaceted and involves methodological, analytical, theoretical, and ethical components.

The structural path linking Investigative Interests and Research Training Environment to the research self-efficacy of STEM graduates provides a theoretical basis of the model, as shown in Figure 2 below. The significant positive influence indicates that students' interest in research and access to quality learning environments serve as antecedents to advanced research self-efficacy. In practical terms, this means that early exposure to research training, mentorship, inquiry processes, and writing practice strengthens the confidence of students to formulate research questions, construct theoretical frameworks, design appropriate methods, analyze data, interpret findings, and conduct ethically responsible research.

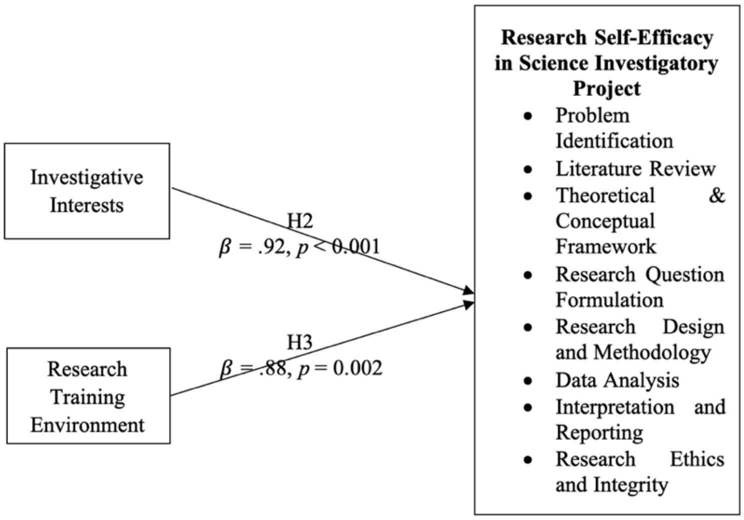

Figure 2. Structural Equation Model on STEM Graduates' Research Self-Efficacy

Social Cognitive Processes, Investigative Interest, Research Training Environment, Self-Efficacy (SIRSE) Model: A Research Self-Efficacy Model

The figure below provides a structured explanation of how students develop confidence in conducting research. It highlighted the interaction of foundational factors, cognitive processes, and research confidence in this model. It emphasized that research self-efficacy is not formed instantly but rather emerges through a progressive and mediated learning pathway.

Grounded in these findings, a model on STEM research self-efficacy was developed namely SIRSE (Social Cognitive Processes, Investigative Interest, Research Training Environment, Self-Efficacy) Model to illustrate the relationships among the identified variables. The model depicts Investigative Interest and Research Training Environment as key exogenous factors that directly influence research self-efficacy on the components of the research processes mediated by the four key cognitive learning processes such as Attention, Retention, Reproduction, and Motivation that transform foundational conditions into actual research confidence.

Figure 3. Social Cognitive Processes, Investigative Interest, Research Training Environment, Self-Efficacy (SIRSE) Model

After students get through the cognitive mediation stages, they can get involved in the eight components of the research process. This was showed on the arrow going up to the octagon wherein the eight (8) domains of a science investigatory project were listed in a circular path, which symbolizes the hands-on process of doing research. It divides the research task into eight clear and practical areas that a researcher needs to handle. The way these parts are arranged in a circle with arrows pointing inward shows that each one helps build up research skills as a whole. It also means that doing research is not just a straight line but more like a cycle where students keep improving their skills by practicing and thinking about what they have done. Hence, mastering each individual component directly contributes to the overall success of the research task.

Lastly, the last arrow shows the journey from exhibiting the foundational manifestations of a researcher, as mediated by the cognitive processes, to the actual conduct of the research task, shows the end result of the whole process. When students do well with the different parts of the research process, they gain mastery experiences, which Bandura says are the strongest way to build self-efficacy. Through repeated engagement such as students gaining confidence in their ability to conduct research, developing strength when faced with challenges, and becoming more willing to undertake complex research tasks, research self-efficacy emerges as an outcome of successful cognitive processing and performance. This starts with Investigative Interest and Research Training Environment, which provide the necessary foundation, mediated by Social Cognitive Learning Processes, which explains how learning occurs, followed by the Research Process that represent what students do, and lastly Research Self-Efficacy, which reflects what students believe they can do.

5. Conclusion and Recommendations

Based on the findings of the study, STEM graduates are confident in following the necessary steps in conducting research ethics and guidelines. However, they are faced with difficulties in transforming raw data into valuable insights, interpretation, and implications using appropriate statistical tools and techniques for data analysis. On the other hand, the extent of teacher mentorship was highly observed towards STEM graduates' ability to conduct science investigatory project but instances like inadequate research facilities, learning resources, and institutional support hinder their research ability to a high extent. Also, the level of STEM graduates' research self-efficacy and the factors that predict research self-efficacy are all significantly correlated, but not all are really predictors. The correlation output did not imply direct causation, meaning only Investigative Interest and Research Training Environment predicts research self-efficacy. Further, Investigative Interest and Research Training Environment significantly and positively influence STEM graduates' ability to conduct science investigatory project. Hence, SIRSE (Social Cognitive Processes, Investigative Interest, Research Training Environment, Self-Efficacy) Model was established, which represents a model that visualizes the path of student's interest and curiosity as well as the learning environment they are placed as foundational manifestations of a confident researcher mediated by the Social Cognitive Learning Process towards enhancing student's research self-efficacy.

In light of the findings and conclusions of this study, the study recommends that Surigao del Norte National High school may implement hands-on data analysis workshops to students to help them choose the appropriate statistical techniques for data analysis as well as create targeted upskilling workshops to enable students manipulate statistical software to develop the skill of data cleaning visualization and interpreting results to solve specific problems relevant to their subject. On the other hand, the school may establish a research and development budget line to cover laboratory expenses for testing, invest in robotics and innovation expo materials, and access to high end laboratory apparatus for students to perform in-house experimentation, ensuring that students are not hindered by a lack of basic research materials. Also, the school must cultivate genuine interest and scientific interest/curiosity first, since enthusiasm is an essential building block for researchers. But this finding is context-specific and requires validation across diverse educational settings. Likewise, research teachers are encouraged to shift their role from a direct to facilitator by providing guidance and support during the initial stages of the research process, gradually allowing students to take ownership of their work. Lastly, DepEd may use the Research Self-Efficacy Model of this study to recalibrate the Strengthened Senior High School curriculum.

Declarations

Funding

The research did not receive financial support.

Credit Authorship Contribution Statement

Author A: Conceptualization, Methodology, Data Analysis, Writing – Original Draft, Data Collection, Formal Analysis
Author B: Validation, Supervision, Writing – Review and Editing.

Ethical Statement

Informed consent was obtained from all participants. Data privacy compliance followed Republic Act 10173 (Data
Privacy Act of 2012).

Declaration of Competing Interest

The authors declare no competing financial, personal, institutional, or professional interests.

Data Availability Statement

Data are available upon reasonable request.

AI Usage Disclosure

No AI-assisted tools were used in the preparation of this manuscript.

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