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Students' Collaborative Skills and Performance in Science Through Steam-Based Integrated Laboratory Activities

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Abstract*—This study examines the utilization of STEAM-based integrated laboratory activities and their relationship with students' collaborative skills and performance in science. It is based on the increasing emphasis on 21st-century skills in science education, particularly collaboration and meaningful learning through interdisciplinary approaches. However, despite the growing adoption of STEAM-based laboratory activities, empirical evidence remains limited regarding their relationship with students' collaborative skills and cognitive performance in science classrooms, particularly in the local Philippine context. The study employed a quantitative descriptive-correlational research design. The respondents consisted of 49 Grade 10 students from Sampaloc National High School during the School Year 2025–2026, selected through total enumeration. A researcher-made questionnaire was used to determine the level of implementation of STEAM-based laboratory activities and the level of students' collaborative skills, while performance assessment rubrics were utilized to measure students' cognitive learning outcomes in science. Data were analyzed using weighted mean, standard deviation. Pearson Product-Moment Correlation and regression analysis (t-test). The findings reveal that the utilization of STEAM-based integrated laboratory activities was at a very high level. Results further show that students demonstrated a very high level of collaborative skills, particularly in flexibility and adaptability, open-mindedness, cooperation and support, and conflict resolution. However, students' cognitive learning outcomes, as evaluated by performance-based assessments, are deemed to be at an acceptable level, suggesting adequate but varied competence of scientific abilities. Statistical analysis show that the utilization of STEAM-based laboratory activities did not have a significant overall relationship with students' collaborative skills nor a significant effect on their cognitive performance, although problem-centered activities show limited associations with selected collaboration indicators. Based on these findings, the null hypotheses stating that there is no significant relationship between STEAM-based laboratory activities and students' collaborative skills, and no significant effect on students' performance, were accepted. Teachers are encouraged to continue implementing STEAM-based laboratory activities. School administrators and curriculum developers may facilitate professional development opportunities to enhance the effective facilitation of STEAM activities. Future researchers may conduct additional studies, enhanced utilization and more diverse samples, and consider longitudinal or experimental designs to better determine the long-term impact of STEAM-based learning on students' collaborative skills and academic performance.*

***Keywords*—** *Steam-Based, collaborative skills, student's performance, interdisciplinary.*

I. Introduction

The education system is about more than just gaining information; it is also about developing skills that will help you throughout your life, and be successful, even when the world we live in changes rapidly. Technology, economics, and social changes necessitate giving learners the skills they will need to work in jobs that have not been established yet. For example, STEAM (Science, Technology, Engineering, Arts and Mathematics) is becoming an important teaching method in schools, which will help students develop their critical thinking abilities, creativity, the ability to collaborate with others, and the ability to solve problems. STEAM allows students to do hands-on, interdisciplinary lab work that combines what they have learned in school with what they will eventually experience in real life. Therefore, teachers too must be adaptable, committed to lifelong learning, technologically savvy, open-minded and committed advocates for their students and for their profession.

To fulfill these expectations, educators need to use creative tools and methods that ensure education is relevant to today's world and produces skilled graduates. Some of the many creative methods include STEAM-based integrated performance tasks, which have become prominent in the development of students overall.

STEAM-based integrated performance tasks differ from more traditional subject-specific teaching models due to the hands-on, project-based work in which students participate in real-world applications of discipline-based concepts to develop solutions, build prototypes, and present what they have developed. Integrated performance tasks provide students with the opportunity to engage with the materials they are studying more fully than they typically would in a more traditional educational setting.

Successful completion of STEAM integrated performance tasks requires that students work collaboratively; collaboration is one of the required 21st-century skills. Many STEAM integrated performance tasks require students to be able to brainstorm, assign roles, and work as a team to accomplish their goals.

In addition to being a major indicator of a student's achievement level, performance tasks provide evidence that a student has mastered any particular body of knowledge and has learned how to express their own understanding through a

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variety of different assessments and outputs. When performance tasks are conducted in a STEAM (Science, Technology, Engineering, Arts & Mathematics) context, it provides students with the opportunity to integrate skills and knowledge from numerous disciplines into an authentic experience. Performance tasks further allow students to work together collaboratively to complete a project, solve problems, and critically evaluate through experiential learning, as well as build their competence to work effectively with others, while concurrently continuing to build upon existing knowledge through practical application.

The increase in collaboration and the improvement in academic ability of students allows for effective collaboration among group members, thereby facilitating the sharing of knowledge. This study therefore serves to provide insight into the ways in which STEAM-based integrated performance tasks across multiple disciplines can utilize innovative teaching methods to improve both students' interpersonal skills and their overall development as learners.

1.1 Statement of the Problem

Problem/s which were addressed by the research

This study aimed to investigate the use of STEAM-Based Integrated Laboratory Activities in improving students' collaborative skills and student's performance.

Specifically, it sought to determine the impacts of STEAM-based integrated laboratory activities on the level of students' collaborative skills, and the level of their performance.

To address these objectives, the study answered the following questions:

1. What is the level of using STEAM-Based Laboratory Activities in terms of:
   1.1 Interdisciplinary Integration;
   1.2 Hands-on and Experiential Learning;
   1.3 Problem-centered Activities; and
   1.4 Real-world Contextualization?
2. What is the level of students Collaborative Skills in terms of:
   2.1 Flexibility and Adaptability;
   2.2 Open-mindedness;
   2.3 Cooperation and Support; and
   2.4 Conflict Resolution?
3. What is the level of students Performance in Science in terms of Performance task?
4. Does the use of STEAM-Based Integrated Laboratory Activities have a significant relationship on the students' collaborative skills in Science?
5. Does the use of STEAM-Based Integrated Laboratory Activities have a significant effect on the students' performance task in Science?

II. Methodology

The study employed a quantitative descriptive-correlational research design. The respondents consisted of 49 Grade 10 students from Sampaloc National High School during the School Year 2025–2026, selected through total enumeration. A researcher-made questionnaire was used to determine the level of implementation of STEAM-based laboratory activities and the level of students' collaborative skills, while performance assessment rubrics were utilized to measure students' cognitive learning outcomes in science. Data were analyzed using weighted mean, standard deviation. Pearson Product-Moment Correlation and regression analysis (t-test).

III. Results and Discussion

This part presents the results of the study and explains what the data mean based on the responses of the participants. The findings are organized according to the research questions and are shown in tables with their corresponding weighted mean, standard deviation, and verbal interpretation. This helps make the results clearer and easier to understand.

The data were analyzed using weighted mean and standard deviation to describe the level of implementation and the performance of the variables in the study. These statistical tools helped summarize the responses and show patterns in the data in a clear and organized way.

The discussion of results is also supported by related studies to help explain and strengthen the findings. These studies are used to compare and connect the results of the current study with existing research in the field of education, especially in STEAM-based learning and student collaboration.

Overall, this chapter explains the main findings of the study in a clear and simple way. It shows how STEAM-based laboratory activities relate to students' collaborative skills and performance tasks, which serve as the basis for the conclusions and recommendations in the next chapter.

Level of Using of STEAM-Based Laboratory Activities

In this study, the level of Using of STEAM-Based Laboratory Activities in terms of Components refers to Interdisciplinary Integration, Hands-on and Experiential Learning, Problem-Centered Activities, and Real-world Contextualization.

The level of Using of STEAM-Based Laboratory Activities is revealed in the following table, which shows the statement, mean, standard deviation, remarks, and verbal interpretation.

Table 1 presents the level of using STEAM-based laboratory activities in terms of interdisciplinary integration.

Among the indicators, incorporating project-based activities that combine creativity with technical and scientific skills obtained the highest mean score (M = 4.67, SD = 0.66), indicating that this practice is consistently observed in STEAM-based laboratory activities. This is closely followed by designing performance tasks that integrate concepts from science, technology, engineering, arts, and mathematics and facilitating discussions that highlight the relevance of integrating concepts across disciplines, both of which yielded high mean scores (M = 4.65, SD = 0.63 and M = 4.65, SD = 0.69, respectively). These results suggest that teachers strongly emphasized interdisciplinary task design and discussion-based integration to connect concepts across subject areas.

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Table 1. Level of Using of STEAM-Based Laboratory Activities in terms of Interdisciplinary Integration

Statement In carrying out the STEAM-Based Laboratory Activities in terms of Interdisciplinary Integration, my teacher…	Mean	SD	Remarks
…designs performance tasks that integrate concepts from science, technology, engineering, arts, and mathematics.	4.65	0.63	Always
…facilitates discussions that highlight the relevance of integrating concepts across disciplines.	4.65	0.69	Always
…provides learning experiences where subjects are interconnected through real-world tasks.	4.55	0.61	Always
…incorporates project-based activities that combine creativity with technical and scientific skills.	4.67	0.66	Always
…encourages students to explore solutions that require knowledge from multiple subject areas.	4.45	0.77	Always
Weighted Mean	4.60		
SD	0.67		
Verbal Interpretation	Very High		

Meanwhile, providing learning experiences where subjects are interconnected through real-world tasks also demonstrated a high level of implementation (M = 4.55, SD = 0.61). The indicator with the lowest mean, although still interpreted as "Always," is encouraging students to explore solutions that require knowledge from multiple subject areas (M = 4.45, SD = 0.77). This result implies that while multidisciplinary exploration was consistently practiced, it shows slightly greater variability compared to other indicators, suggesting opportunities to further strengthen student-driven integration of knowledge across disciplines.

The level of STEAM-based laboratory activities in terms of interdisciplinary integration attained a very high with a weighted mean of 4.60 and a standard deviation of 0.67, indicating a consistently strong implementation of interdisciplinary practices. This indicates that teachers effectively designed learning experiences that linked multiple disciplines, supporting holistic understanding and meaningful application of knowledge. The findings imply that sustained interdisciplinary integration in laboratory activities can enhance students' capacity to connect concepts, engage in problem-solving, and apply learning to real-world contexts.

Table 2 presents the level of using STEAM-based laboratory activities in terms of hands-on and experiential learning.

Among the indicators, providing students with performance tasks that involve direct experimentation and practice obtained the highest mean score (M = 4.71, SD = 0.58), indicating that direct engagement through experimentation is consistently emphasized in STEAM-based laboratory activities. This is followed by engaging learners in building, designing, or creating tangible outputs (M = 4.45, SD = 0.71) and allowing students to manipulate tools, materials, or technologies in accomplishing tasks (M = 4.45, SD = 0.77), both of which reflect frequent opportunities for active participation and skill application during laboratory activities.

Table 2. Level of Using of STEAM-Based Laboratory Activities in terms of Hands-on and Experiential Learning

Statement In carrying out the STEAM-Based Laboratory Activities in terms of Hands-on and Experiential Learning, my teacher…	Mean	SD	Remarks
…provides students with performance tasks that involve direct experimentation and practice.	4.71	0.58	Always
…engages learners in building, designing, or creating tangible outputs during STEAM activities.	4.45	0.71	Always
…organizes real-life problem-solving tasks where students apply concepts through hands-on work.	4.43	0.71	Always
…allows students to manipulate tools, materials, or technologies in accomplishing tasks.	4.45	0.77	Always
…facilitates experiential activities that simulate authentic situations related to STEAM disciplines.	4.37	0.70	Always
Weighted Mean	4.48		
SD	0.70		
Verbal Interpretation	Very High		

Meanwhile, organizing real-life problem-solving tasks where students apply concepts through hands-on work also showed a very high level of implementation (M = 4.43, SD = 0.71). The indicator with the lowest mean, though still interpreted as "Always," was facilitating experiential activities that simulate authentic situations related to STEAM disciplines (M = 4.37, SD = 0.70). This suggests that while experiential simulations were consistently employed, there is still room to further deepen authenticity and real-world immersion within STEAM laboratory experiences.

Overall, the level of STEAM-based laboratory activities in terms of hands-on and experiential learning attained a very high with a weighted mean of 4.48 and a standard deviation of 0.70. This indicates that teachers effectively implemented experiential strategies that allowed students to actively engage with materials, technologies, and practical tasks. The findings imply that sustained hands-on engagement in STEAM laboratories supports deeper understanding, strengthens skill development, and promotes active learning through direct experience.

Table 3. Level of Using of STEAM-Based Laboratory Activities in terms of Problem-Centered Activities

Statement In carrying out the STEAM-Based Laboratory Activities in terms of Problem-Centered Activities my teacher…	Mean	SD	Remarks
…presents performance tasks that are anchored on real-life problems.	4.49	0.74	Always
…encourages students to analyze issues and identify possible solutions through STEAM integration.	4.43	0.79	Always
…guides learners to apply critical and creative thinking in addressing authentic challenges.	4.45	0.89	Always
…provides open-ended problems that require multiple approaches and disciplinary integration.	4.31	0.87	Always
…develops tasks that require evidence-based reasoning in solving problems.	4.43	0.82	Always
Weighted Mean	4.42		
SD	0.82		
Verbal Interpretation	Very High		

Table 3 presents the level of using STEAM-based laboratory activities in terms of problem-centered activities.

Among the indicators, presenting performance tasks that are anchored on real-life problems obtained the highest mean score (M = 4.49, SD = 0.74), indicating that authentic problem contexts are consistently integrated into STEAM-based laboratory activities. This is followed by guiding learners to apply critical and creative thinking in addressing authentic challenges (M = 4.45, SD = 0.89) and developing tasks that require evidence-based reasoning in solving problems (M = 4.43, SD = 0.82). These results suggest that teachers strongly emphasized analytical thinking, creativity, and justification of solutions when engaging students in problem-centered tasks.

Meanwhile, encouraging students to analyze issues and identify possible solutions through STEAM integration also exhibits a very high level of implementation (M = 4.43, SD = 0.79). The indicator with the lowest mean, though still interpreted as "Always," was providing open-ended problems that require multiple approaches and disciplinary integration (M = 4.31, SD = 0.87). This indicates that while open-ended and integrative problem-solving tasks were frequently used, they showed slightly greater variability, suggesting opportunities to further strengthen student autonomy and multi-approach exploration in problem-solving activities.

Overall, the level of STEAM-based laboratory activities in terms of problem-centered activities attained a very high with a weighted mean of 4.42 and a standard deviation of 0.82. This indicates that teachers consistently implemented problem-centered instructional strategies that challenged students to think critically, apply interdisciplinary knowledge, and engage in meaningful problem-solving. The findings imply that problem-centered STEAM activities effectively support the development of higher-order thinking skills and real-world application of learning.

Table 4. Level of Using of STEAM-Based Laboratory Activities in terms of Real-world Contextualization

Statement In carrying out the STEAM-Based Laboratory Activities in terms of Problem-Centered Activities my teacher…	Mean	SD	Remarks
…relates STEAM activities to community issues and everyday experiences.	4.55	0.71	Always
…integrates local culture, environment, or social concerns into task design.	4.41	0.70	Always
…encourages learners to see the relevance of STEAM concepts in daily life.	4.39	0.81	Always
…develops projects that address current societal or environmental challenges.	4.43	0.76	Always
…implements tasks that prepare students for practical decision-making beyond the classroom.	4.47	0.89	Always
Weighted Mean	4.45		
SD	0.77		
Verbal Interpretation	Very High		

Table 4 presents the level of using STEAM-based laboratory activities in terms of real-world contextualization.

Among the indicators, relating STEAM activities to community issues and everyday experiences obtained the highest mean score (M = 4.55, SD = 0.71), indicating that teachers consistently connected learning tasks to students' immediate environments and real-life situations. This was followed by implementing tasks that prepare students for practical decision-making beyond the classroom (M = 4.47, SD = 0.89) and developing projects that address current societal or environmental challenges (M = 4.43, SD = 0.76). These results suggest a strong emphasis on applying STEAM concepts to authentic contexts that foster relevance, responsibility, and real-world problem engagement.

Meanwhile, integrating local culture, environment, or social concerns into task design also demonstrated a very high level of implementation (M = 4.41, SD = 0.70). The indicator with the lowest mean, though still interpreted as "Always," was encouraging learners to see the relevance of STEAM concepts in daily life (M = 4.39, SD = 0.81). This finding indicates that although relevance-building was consistently practiced, there remains potential to further strengthen explicit connections between STEAM concepts and students' everyday experiences.

Overall, the level of STEAM-based laboratory activities in terms of real-world contextualization attained a very high with a weighted mean of 4.45 and a standard deviation of 0.77. This indicates that teachers effectively embedded real-life contexts into STEAM laboratory instruction, enabling students to understand the practical value of learning and apply knowledge to societal, environmental, and community-related situations. The findings imply that consistent contextualization enhances learners' ability to transfer classroom learning to meaningful real-world applications.

Level of Collaborative Skills of the Students

In this study, the level of Collaborative Skills of the Students refers to Flexibility and Adaptability; Open-mindedness; Cooperation, and Support; and Conflict Resolution.

The level of Collaborative Skills of the Students is revealed in the following table, which shows the statement, mean, standard deviation, remarks, and verbal interpretation.

Table 5 presents the level of collaborative skills of the students as demonstrated through STEAM-based integrated laboratory activities.

Among the indicators, showing willingness to take on different roles in group performance tasks when needed obtained the highest mean score (M = 4.41, SD = 0.79), indicating that students consistently demonstrated flexibility in adapting to various roles during collaborative activities. This was followed by accepting changes in group plans when better approaches were suggested (M = 4.39, SD = 0.76) and remaining open to new perspectives when solving problems with peers (M = 4.37, SD = 0.93). These results suggest that students frequently showed adaptability and openness, which are essential behaviors for effective collaboration in STEAM-based group work.

Meanwhile, contributing ideas even when the group decided to move in another direction also reflected a very high level of practice (M = 4.33, SD = 0.92). The indicator with the lowest mean, though still interpreted as "Always," was managing unexpected challenges effectively during group activities (M = 4.31, SD = 0.87). This implies that while

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students were generally capable of handling unforeseen challenges, there is still room to further strengthen resilience and problem management skills during collaborative tasks.

Table 5. Level of Collaborative Skills of the Students refers to Flexibility and Adaptability; Open-mindedness; Cooperation, and Support; and Conflict Resolution

Statement Through STEAM-Based Integrated Laboratory Activities, I am able to…	Mean	SD	Remarks
…show willingness to take on different roles in group performance tasks when needed.	4.41	0.79	Always
…accept changes in group plans when better approaches are suggested.	4.39	0.76	Always
…contribute ideas even when the group decides to move in another direction.	4.33	0.92	Always
…remain open to new perspectives when solving problems with peers.	4.37	0.93	Always
…manage unexpected challenges effectively during group activities.	4.31	0.87	Always
Weighted Mean	4.36		
SD	0.85		
Verbal Interpretation	Very High		

Overall, the level of collaborative skills attains a very high with a weighted mean of 4.36 and a standard deviation of 0.85. This indicates that students demonstrated strong collaborative competencies, particularly in terms of flexibility, adaptability, and openness during STEAM-based laboratory activities. The findings imply that structured, interdisciplinary laboratory tasks effectively promote cooperative engagement and constructive interaction among learners.

These results emphasize the role of collaboration as a critical outcome of STEAM-based instruction. Consistent with Vygotsky's Sociocultural Theory, learning is enhanced through social interaction, particularly within the Zone of Proximal Development, where students benefit from peer collaboration and shared problem-solving experiences. STEAM-based laboratory activities that require role-sharing, idea exchange, and collective decision-making create supportive learning environments that foster students' collaborative skills and prepare them for teamwork in both academic and real-world contexts.

Table 6. Level of Collaborative Skills of the Students refers to Open-mindedness

Statement Through STEAM-Based Integrated Laboratory Activities, I am able to…	Mean	SD	Remarks
…listen attentively to ideas shared by group members during tasks.	4.65	0.72	Always
…consider different perspectives before making group decisions.	4.55	0.68	Always
…accept constructive feedback from peers without resistance.	4.45	0.68	Always
…show respect for suggestions even when they differ from personal opinions.	4.61	0.70	Always
…remain open to alternative solutions proposed by the group.	4.45	0.89	Always
Weighted Mean	4.54		
SD	0.74		
Verbal Interpretation	Very High		

Table 6 presents the level of collaborative skills of the students in terms of open-mindedness as demonstrated through STEAM-based integrated laboratory activities.

Among the indicators, listening attentively to ideas shared by group members during tasks obtained the highest mean score (M = 4.65, SD = 0.72), indicating that students consistently practiced active listening during collaborative activities. This was followed by showing respect for suggestions even when they differed from personal opinions (M = 4.61, SD = 0.70) and considering different perspectives before making group decisions (M = 4.55, SD = 0.68). These results suggest that students frequently demonstrated openness, respect, and receptiveness to diverse viewpoints, which are essential characteristics of effective collaboration in STEAM-based group tasks.

Meanwhile, accepting constructive feedback from peers without resistance and remaining open to alternative solutions proposed by the group both recorded high mean scores (M = 4.45, SD = 0.68 and M = 4.45, SD = 0.89, respectively). Although these indicators are still interpreted as "Always," their slightly higher standard deviations indicate greater variability in students' responses, suggesting that openness to feedback and alternative ideas may differ depending on group dynamics or task complexity.

Overall, the level of collaborative skills in terms of open-mindedness attained a very high with a weighted mean of 4.54 and a standard deviation of 0.74. This indicates that students demonstrated a strong level of open-mindedness during STEAM-based laboratory activities, allowing them to engage meaningfully in group discussions, respect differing opinions, and participate constructively in decision-making processes. The findings imply that STEAM-based collaborative tasks effectively nurture inclusive and respectful learning environments.

Table 7. Level of Collaborative Skills of the Students refers to Cooperation and Support.

Statement Through STEAM-Based Integrated Laboratory Activities, I am able to…	Mean	SD	Remarks
…share resources and materials willingly during group tasks.	4.59	0.64	Always
…assist group members who encounter difficulties in completing their tasks.	4.55	0.68	Always
…work collaboratively to achieve common goals in performance activities.	4.55	0.71	Always
…encourage peers to participate actively in group discussions and tasks.	4.61	0.61	Always
…offer help to ensure all members understand the requirements of the task.	4.73	0.53	Always
Weighted Mean	4.61		
SD	0.63		
Verbal Interpretation	Very High		

Table 7 presents the level of collaborative skills of the students in terms of cooperation and support as demonstrated through STEAM-based integrated laboratory activities.

Among the indicators, offering help to ensure all members understand the requirements of the task obtained the highest mean score (M = 4.73, SD = 0.53), indicating that students consistently demonstrated initiative in supporting peer

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understanding during group tasks. This is followed by encouraging peers to participate actively in group discussions and tasks (M = 4.61, SD = 0.61) and sharing resources and materials willingly during group tasks (M = 4.59, SD = 0.64). These results suggest that students frequently engaged in supportive behaviors that promote inclusivity, participation, and teamwork in collaborative STEAM activities.

Meanwhile, assisting group members who encountered difficulties in completing tasks and working collaboratively to achieve common goals in performance activities both demonstrated very high levels of practice (M = 4.55, SD = 0.68 and M = 4.55, SD = 0.71, respectively). Although these indicators were still interpreted as "Always," their slightly higher standard deviations indicate some variability in students' collaborative experiences, which may be influenced by group roles, task complexity, or individual confidence levels.

Overall, the level of collaborative skills in terms of cooperation and support attains a very high with a weighted mean of 4.61 and a standard deviation of 0.63. This indicates that students consistently exhibited cooperative behaviors and actively supported their peers during STEAM-based laboratory activities. The findings imply that structured collaborative tasks effectively cultivate shared responsibility, mutual assistance, and collective problem-solving among learners.

Table 8. Level of Collaborative Skills of the Students in terms of Conflict Resolution

Statement Through STEAM-Based Integrated Laboratory Activities, I am able to…	Mean	SD	Remarks
…address disagreements in a respectful and constructive manner during group tasks.	4.57	0.65	Always
…listen to all sides of an argument before reaching a group decision.	4.53	0.74	Always
…seek compromise when differing opinions arise among group members.	4.43	0.68	Always
…focus on solving the problem rather than blaming others during conflicts.	4.71	0.50	Always
…encourage open dialogue to clarify misunderstandings in the group.	4.61	0.64	Always
Weighted Mean	4.57		
SD	0.65		
Verbal Interpretation	Very High		

Table 8 presents the level of collaborative skills of the students in terms of conflict resolution as demonstrated through STEAM-based integrated laboratory activities.

Among the indicators, focusing on solving the problem rather than blaming others during conflicts obtained the highest mean score (M = 4.71, SD = 0.50), indicating that students consistently demonstrated maturity and responsibility when handling disagreements during group tasks. This is followed by encouraging open dialogue to clarify misunderstandings in the group (M = 4.61, SD = 0.64) and addressing disagreements in a respectful and constructive manner during group tasks (M = 4.57, SD = 0.65). These results suggest that students frequently practiced constructive communication and solution-oriented behaviors when conflicts arose in collaborative STEAM activities.

Meanwhile, listening to all sides of an argument before reaching a group decision also showed a very high level of practice (M = 4.53, SD = 0.74). The indicator with the lowest mean, though still interpreted as "Always," is seeking compromise when differing opinions arise among group members (M = 4.43, SD = 0.68). This finding indicates that while students generally demonstrated effective conflict management skills, negotiating compromises may still present challenges depending on group dynamics or task complexity.

Overall, the level of collaborative skills in terms of conflict resolution attains a very high with a weighted mean of 4.57 and a standard deviation of 0.65. This indicates that students consistently exhibited effective conflict resolution behaviors during STEAM-based laboratory activities. The findings imply that structured collaborative tasks provide learners with opportunities to practice respectful communication, shared decision-making, and constructive problem-solving when disagreements occur.

These results underscore the importance of conflict resolution as a key component of collaborative learning in STEAM education. By engaging students in group-based laboratory activities that require discussion, negotiation, and collective problem-solving, STEAM-based instruction supports the development of interpersonal skills essential for managing differences productively. Such competencies prepare students to work effectively in team-oriented academic settings and future professional environments where collaboration and conflict management are critical.

Level of Performance of the Students

In this study, the Level of Performance of the Students refers to Performance Assessment Using Rubrics.

The level of Students' Cognitive Learning Outcomes is revealed in the following table, which shows the raw score, frequency, percentage, mean, standard deviation, and verbal interpretation.

Table 9. Level of Students' Cognitive Learning Outcomes in terms of Performance Assessment

Scale	f	%	Descriptive Equivalent
90 - 100	16	32.65	Outstanding
85 - 89	7	14.29	Very Satisfactory
80 - 84	9	18.37	Satisfactory
75 - 79	8	16.33	Fairly Satisfactory
Below 75	9	18.37	Did Not Meet Expectations
Total	49	100.00	
Mean	=		83.47
SD	=		9.19
VI`	=		Satisfactory

Table 9 presents the level of students' cognitive learning outcomes in terms of performance assessment.

In terms of score distribution, the largest proportion of students falls within the Outstanding range (90–100), with 16 students (32.65%), indicating that a considerable number of learners demonstrated high mastery of the assessed competencies. This is followed by students who obtained Satisfactory scores (80–84), with 9 students (18.37%), and those who were categorized as Did Not Meet Expectations (below 75), also comprising 9 students (18.37%). Meanwhile,

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8 students (16.33%) achieved Fairly Satisfactory performance (75–79), and 7 students (14.29%) fell under the Very Satisfactory category (85–89). These results reflect a varied distribution of performance levels, suggesting differences in students' mastery as measured through performance-based tasks.

Overall, the students' cognitive learning outcomes attained a mean score of 83.47 and a standard deviation of 9.19, which is verbally interpreted as Satisfactory. This indicates that, on average, students demonstrated adequate understanding and application of the concepts assessed through performance tasks. The relatively higher standard deviation suggests variability in students' performance, implying that while many students excelled, others encountered challenges in meeting expected performance standards.

In general, the findings indicate that students achieved satisfactory cognitive learning outcomes when assessed through performance-based tasks. This implies that instructional strategies, including STEAM-based laboratory activities and collaborative learning experiences, supported students' conceptual understanding and skill application, though additional support may be needed to assist learners who struggled to meet expectations. Strengthening scaffolding, feedback mechanisms, and differentiated instruction may further enhance overall student performance.

Significant Relationship between the Utilization of STEAM-Based Laboratory Activities to the Collaborative Skills of the Students

In this study, the level of Using of STEAM-Based Laboratory Activities in terms of Components refers to Interdisciplinary Integration, Hands-on and Experiential Learning, Problem-Centered Activities, and Real-world Contextualization while the Collaborative Skills of the Students refers to Flexibility and Adaptability; Open-mindedness; Cooperation, and Support; and Conflict Resolution.

The Significant Relationship between the Utilization of STEAM-Based Laboratory Activities to the Collaborative Skills of the Students is revealed in the following table, which shows the Multiple Regression Analysis using Pearson Product Moment Correlation Coefficient or Pearson-r, p-value, and number of observation or respondents.

Table 10 shows the Significant Relationship between the Utilization of STEAM-Based Laboratory Activities to the Collaborative Skills of the Students.

Table 10 shows the significant relationship between the utilization of STEAM-based laboratory activities and the collaborative skills of the students in terms of flexibility and adaptability, open-mindedness, cooperation and support, and conflict resolution. The results indicate that most of the correlations between STEAM-based laboratory activities and the dimensions of collaborative skills are not statistically significant, as evidenced by p-values greater than 0.05.

Table 10. Significant Relationship between the Utilization of STEAM-Based Laboratory Activities and the Collaborative Skills of the Students

STEAM-Based Activities	Laboratory	Collaborative Skills of the Students: Flexibility and Adaptability	Open-mindedness	Cooperation and Support	Conflict Resolution
Interdisciplinary Integration	Pearson Correlation	0.039	0.030	0.075	0.035
	Sig. (2-tailed)	0.792	0.836	0.610	0.811
	N	49	49	49	49
Hands-on and Experiential Learning	Pearson Correlation	0.016	0.096	0.086	0.257
	Sig. (2-tailed)	0.915	0.512	0.558	0.075
	N	49	49	49	49
Problem-Centered Activities	Pearson Correlation	0.255	0.312*	0.281	0.304*
	Sig. (2-tailed)	0.077	0.029	0.051	0.034
	N	49	49	49	49
Real-world Contextualization	Pearson Correlation	0.077	0.087	0.159	0.189
	Sig. (2-tailed)	0.600	0.552	0.274	0.195
	N	49	49	49	49

Specifically, interdisciplinary integration and hands-on and experiential learning show low correlations with all dimensions of collaborative skills, suggesting that these aspects of STEAM activities do not have a significant influence on students' flexibility and adaptability, open-mindedness, cooperation, and conflict resolution. Real-world contextualization also demonstrates no significant relationship with collaborative skill dimensions, indicating that connecting STEAM activities to daily life or community issues alone does not automatically translate into improved teamwork skills.

On the other hand, problem-centered activities reveal significant relationships with students' open-mindedness and conflict resolution, with p-values of 0.312 and 0.304, respectively. This indicate that tasks anchored on real-life problems encourage students to consider different perspectives and work through disagreements constructively.

The findings indicate that while STEAM-based laboratory activities generally do not have a strong overall relationship with collaborative skills, problem-centered activities can effectively promote critical aspects of collaboration, particularly open-mindedness and conflict resolution. Teachers may therefore focus on designing real-world problem-solving tasks to enhance students' ability to work together effectively.

Bhattacharjya researched how automation will transform the workforce and future of education in his 2025 study. The study looked at how current teaching and learning approaches (called "transdisciplinary educational models") need to evolve to prepare students for jobs in workforces that are impacted by automation. Analyzing the shift from science, technology, engineering, and math (STEM) to science, technology, engineering, arts and mathematics (STEAM), the research evaluated how inclusion of arts in the classroom supports student success; influences their attitudes and creativity while nurturing their resilience, creativity and development of a sustainable skillset.

The research also provides innovative descriptions of potential STEAM learning models that provide students with all of the resources necessary to succeed. creating an informed base of information for policymakers and teachers on how to future-proof education so that students will have the skills and knowledge to meet the demands of an automated workforce.

Significant Effect between the Utilization of STEAM-Based Laboratory Activities on the Performance of the Students

In this research, the Integration of STEAM-Based Laboratory Activities into Practice refers to the use of Interdisciplinary Integration, Hands-on and Experiential Learning, Problem-Based Activities, and Real-World Contexts, while Student Performance refers to Student Performance Assessment via Rubrics.

Table 11 presents the goodness of fit of the Student Utilization of STEAM-Based Laboratory Activities on Student Academic Performance through Multiple Regression Analysis via the t-Test, displaying the calculated t value (t-cal), p-value, number of participants, t critical (t-crit), and constant.

Table 11 shows the Significant Effect between the Utilization of Scienergy as a Mobile-Based Laboratory Manual on the Students' Cognitive Learning Outcomes.

Table 11. Significant Effect between the Utilization of STEAM-Based Laboratory Activities on the Performance of the Students

STEAM-Based Activities	Laboratory	Performance of the Students in terms of Performance Assessment Using Rubrics
Pre-Lab Discussion	t-value	-0.454
	Sig. (2-tailed)	0.652
	N	49
Laboratory Procedures	t-value	-0.804
	Sig. (2-tailed)	0.425
	N	49
Glossary	t-value	-0.556
	Sig. (2-tailed)	0.581
	N	49
Exercises	t-value	-0.428
	Sig. (2-tailed)	0.670
	N	49

Constant=2.011

Table 11 presents the significant effect of the utilization of STEAM-based laboratory activities on the students' performance in terms of performance assessment using rubrics. The results reveal that none of the STEAM activity components—pre-lab discussion, laboratory procedures, glossary, and exercises—have a statistically significant effect on students' performance, as all t-values are low and the corresponding p-values are greater than 0.05. Specifically, the t-values for pre-lab discussion, laboratory procedures, glossary, and exercises are -0.454, -0.804, -0.556, and -0.428, with p-values of 0.652, 0.425, 0.581, and 0.670, respectively.

These findings indicate that the utilization of STEAM-based laboratory activities, when considered individually, does not significantly predict the students' performance in performance assessments using rubrics. This indicate that while STEAM activities provide engaging and interdisciplinary learning experiences, their direct effect on measurable performance outcomes may be influenced by other factors such as students' prior knowledge, instructional support, or individual differences.

In summary, the results imply that teachers should integrate STEAM-based activities with targeted instructional strategies, scaffolding, and guidance to maximize their potential impact on student performance.

According to Maricic and Lavicza (2024), the potential benefit of integrating new technology (in this case, via virtual simulations [VS]) with STEAM activities may be an increase in the perceived engagement of students. They observed that with greater amounts of STEAM activity involvement, students overall perceived higher levels of engagement. In addition, as students spend proportionally larger amounts of time working on VS, they exhibit greater development of the characteristics associated with attentive listening, focusing ones attention, and adding effort towards learning. The order in which VS were integrated into STEAM activities impacted students' perceived engagement as students who completed STEAM activities associated with VS prior to STEAM activity engagement perceived the highest levels of engagement using VS.

IV. Conclusion and Recommendations

There is no significant relationship between the utilization of STEAM-Based Integrated Laboratory Activities and the students' collaborative skills in science. Although the results showed that both the level of STEAM implementation and the students' collaborative skills were very high, statistical analysis revealed that these variables were not significantly associated. This indicates that the presence of well-implemented STEAM laboratory activities alone does not necessarily predict or determine students' collaborative skills. Therefore, the first null hypothesis, which states that there is no significant relationship between STEAM-based laboratory activities and students' collaborative skills, is accepted.

The utilization of STEAM-Based Integrated Laboratory Activities has no significant effect on students' performance in science as measured through performance-based assessments. While students demonstrated satisfactory cognitive learning outcomes and STEAM activities were highly implemented, regression analysis showed that STEAM-based laboratory activities did not significantly predict students' academic performance. This suggests that academic performance in science may depend on multiple interacting factors beyond instructional approach, including prior knowledge, assessment design, scaffolding, and individual learner differences. Hence, the second null hypothesis, which states that there is no significant effect of STEAM-based laboratory activities on students' performance, is likewise accepted.

Based on the drawn conclusions resulted to the following recommendations:

Student may engage in STEAM-based laboratory activities and participate in cultural practice-related tasks to enhance collaborative skills and improve performance outcomes. Students are encouraged to take initiative in group problem-solving and apply cultural knowledge in practical activities.

Jessica Laut Mandaing, "Students' Collaborative Skills and Performance in Science Through Steam-Based Integrated Laboratory Activities," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 9, Issue 2, pp. 678-686, July 2026.

Teachers may design and implement more interdisciplinary STEAM activities. Teachers should provide guidance and scaffolding to ensure students can connect theoretical concepts to real-life applications and collaborate effectively.

Curriculum developers and educational policymakers may consider incorporating STEAM-based laboratory activities and cultural practices into the curriculum more systematically. Guidelines and training modules should be developed to support teachers in delivering activities that promote collaboration, problem-solving, and cultural understanding.

Future researchers may further investigate the factors affecting students' collaborative skills and performance in STEAM and cultural activities, including classroom environment, teacher facilitation, and students' prior knowledge. Longitudinal studies can provide deeper insights into the sustained impact of these instructional strategies.

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