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Science Fair Involvement and Its Role in the Development 21st Century Skills Among STEM Students

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Abstract

Aim: Science and Technology Fairs promote 21st-century competencies through research-driven, student-centered activities. This study examined STEM students' involvement in the South Cotabato Division Science and Technology Fair, assessing their engagement and development of critical thinking, collaboration, communication, and problem-solving skills, and analyzing how involvement predicts overall skill growth.

Methodology: This study utilized a descriptive correlational research design using survey questionnaire. It was conducted within the Division of South Cotabato, specifically at Banga National High School, Libertad National High School, T'boli National High School, Tupi National High School, Poblacion Polomolok National High School, and Polomolok National High School. A total of 106 respondents were selected through total enumeration, encompassing all STEM students who participated in the Division Science and Technology Fair.

Results: The results indicated that STEM students demonstrated a high level of involvement in the Science and Technology Fair, with an overall mean score of 4.39, indicating "Extremely Involved" participation across activities such as research preparation, presentations, and feedback sessions. They also exhibited an extremely developed level of 21st-century skills, particularly in critical thinking and collaboration (M = 4.22), along with highly developed skills in communication (M = 4.15), and problem-solving (M = 4.19). Statistical analysis confirmed that fair participation significantly predicts skill development (B = 1.157, β = 0.649, p = 0.000), with 42.2% of the variance explained by their involvement.

Conclusion: In conclusion, STEM students' strong involvement in the Science and Technology Fair significantly contributes to the development of their 21st-century skills. Their active participation is closely linked to enhanced critical thinking, collaboration, communication, and problem-solving highlighting the fair's role as an effective tool for experiential learning and skill-building.

Keywords: 21st Century Skills, Experiential Learning, Involvement, Science and Technology Fair, STEM Students

INTRODUCTION

Science and Technology education equips students with 21st-century skills, for instance critical thinking, communication, collaboration and problem-solving. With advancing technology and global challenges, the need for a skilled workforce increase. STEM education, especially through Science and Technology fairs, promotes scientific knowledge and fundametal skills desired for workforce success.

Science and Technology fairs promote hands-on learning, interdisciplinary collaboration, and creativity, helping students develop digital-age skills like data analysis, coding, and technological problem-solving through teamwork (Baltikian et al., 2024). These fairs build practical skills while reinforcing critical thinking and problem-solving, essential components of 21st-century competencies. Innovative approaches, such as interactive learning adventures, further enhance STEM engagement through modern learning theories (Taylor, 2024). Science fairs boost students' confidence, interest in STEM careers, and understanding of STEM subjects (Sphero, 2024).

Integrating 21st-century skills into STEM education in the Philippines aligns with international education standards. The Commission on Higher Education (CHED) and the Department of Education (DepEd, 2019) have

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revised curricula to emphasize critical thinking, creativity, and problem-solving. Science and Technology fairs play a vital role in these efforts, contributing to the development of these essential skills. To further promote scientific literacy and innovation, the Science-Technology-Society (STS) approach has been introduced (Acut & Antonio, 2023), while the Department of Science and Technology (2024) continues to enhance STEM education by integrating digital technologies.

In South Cotabato, Science and Technology fairs have become an integral part of the school curriculum, providing students with valuable opportunities for problem-solving and collaboration. These fairs significantly contribute to developing 21st-century skills such as scientific literacy and creativity. A local study by Carillo et al. (2021) emphasized the importance of integrating these critical skills into curricula to enhance student performance, particularly in English. The Division Science and Technology Fair 2022, organized by DepEd RXII SDO Sarangani (2022), highlighted the significance of such events in promoting critical thinking and collaboration, reinforcing their positive impact on student development.

Research has examined student engagement in science fairs, but their role in developing teamwork, innovation, and scientific literacy as key to success in a technology-driven job market remains underexplored. Studies examining the role of science fairs on collaboration and innovation remain scarce (Schmidt & Kelter, 2017; Grinnell, 2020), and there is a lack of analysis on how these fairs contribute to students' ability to critically evaluate scientific articles and engage in scientific discourse (UNESCO, 2021). This gap is particularly important as DepEd recognizes that current teaching methods may not sufficiently foster critical thinking in science education (Lansangan & Orleans, 2024).

The 2022 PISA results show Filipino students lag in reading, math, and science, underscoring the need for educational reforms that influence science fairs to enhance critical thinking and problem-solving (Ombay, 2024). Science fairs that emphasize inquiry-based learning help bridge these gaps by nurturing essential skills for a technology-driven world.

This study focused on resolving this research gap by assessing the impact of Science and Technology fairs on the development of 21st-century skills among STEM students through surveys and interviews. Specifically, it explores STEM students' level of involvement in science and technology fairs, their development of 21st-century skills, how their level of involvement predicts overall skill development, and how participation in these fairs contributes to their skill development. This study seeks to provide evidence-based recommendations to improve STEM curriculum, strengthen scientific literacy, and enhance students' workforce and academic readiness.

Objectives

This study determined the involvement of STEM students during the South Cotabato Division Science and Technology Fair. It answered the following questions:

1. What is the level of involvement of STEM students in science and technology fairs?
2. What is the level of development of 21st-century skills among STEM students, specifically in terms of critical thinking, collaboration, communication, and problem-solving?
3. How does the level of involvement of STEM students in the Science and Technology Fair predict their overall level of development in 21st-century skills?

Hypothesis

Given the stated research problem, the research hypotheses were tested on 0.05 level of significance:

H_o: The level of involvement of STEM students in the Science and Technology Fair does not significantly predict their overall level of development in 21st-century skills.

METHODS

Research Design

A descriptive-correlational research design was used to assess STEM students' involvement in the Division Science and Technology Fair and its role on their development of 21st-century skills, such as critical thinking, collaboration, communication, and problem-solving.

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Population and Sampling

The study was conducted from December 2024 to February 2025 in six secondary schools in the Division of South Cotabato, involving 106 STEM students who participated in the Division Science and Technology Fair through total enumeration.

Instrument

The study employed two structured questionnaires: a researcher-made instrument developed by the researchers based on the *Science and Technology Fair Handbook* (DepEd, 2023) to measure involvement, and an adapted questionnaire from Kelley et al. (2019) to assess 21st-century skills. Both instruments utilized a 5-point Likert scale and the mean range interpretation from Manyange et al. (2015). The questionnaires were validated by six experts.

Data Collection

The researchers obtained approval from the Dean of Graduate Studies at Sultan Kudarat State University and the South Cotabato Schools Division Office before requesting access to six participating schools. The survey was explained to STEM students during orientation sessions highlighting voluntary participation and confidentiality. Data were collected digitally via Google Forms shared through DSTF coaches' group chats, with coaches assisting in clarifying incomplete responses. The responses were then statistically analyzed to identify relevant patterns and relationships.

Treatment of Data

The data were analyzed using mean and standard deviation to describe STEM students' level of involvement and development in 21st-century skills. Simple linear regression was applied to determine the relationship between their involvement in the Science and Technology Fair and their overall skill development.

Ethical Considerations

The study prioritized respondents' welfare by securing informed consent after school principal approval. STEM students were briefed on the study's purpose, voluntary participation, withdrawal rights, and data protection. Responses were collected anonymously via Google Forms, with access restricted to the researchers, following the Data Privacy Act of 2012. Special care was taken for minors by coordinating permissions and minimizing risks through clear instructions and a supportive environment. The study upheld ethical standards to ensure accountability and safeguard participant rights.

RESULTS and DISCUSSION

This sections presents and analyzes the data in response to the research questions. Findings are organized in tables for clarity, with each dataset highlighting trends and patterns. Appropriate analytical methods ensure consistent interpretation, following the problem statement for a focused discussion.

Level of Involvement of STEM Students in Science and Technology Fair

Table 1
Level of Involvement of STEM Students in Science and Technology Fair (n=106)

Indicator	Mean	SD	Verbal Description
1. Participated in the pre-screening to meet the School Research Committee standards.	4.41	0.73	Extremely Involved
2. Applied the coach's technical assistance to improve the research paper.	4.63	0.57	Extremely Involved
3. Completed the research paper on time and meet the Science and Technology Fair requirements.	4.40	0.73	Extremely Involved
4. Contributed to preparing the PowerPoint and research poster to showcase the innovation.	4.56	0.65	Extremely Involved
5. Thoroughly prepared to present the research study effectively.	4.26	1.18	Extremely Involved

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6. Helped set up and organize the tarpaulin display at the Science and Technology Fair venue.	4.43	1.01	Extremely Involved
7. Confidently presented the research innovation to the evaluators.	4.18	0.99	Highly Involved
8. Answered the evaluators' questions clearly and confidently.	4.02	1.04	Highly Involved
9. Engaged in the feedback session and used evaluators' feedback to improve my/our work.	4.43	0.83	Extremely Involved
10. Reflected on experience to identify areas for personal and team growth.	4.58	0.62	Extremely Involved
OVERALL MEAN	**4.39**	**0.54**	**Extremely Involved**

The study revealed that STEM students demonstrated a high level of involvement in the Science and Technology Fair, with an overall mean score of 4.39 (SD=0.54), described as "Extremely Involved". Students were particularly engaged in applying their coach's technical advice (M=4.63, SD=0.57) and reflecting on their experiences for personal and team growth (M=4.58, SD=0.62), highlighting the vital role of mentorship and self-assessment. They also showed strong participation in preparing PowerPoint presentations and research posters (M=4.56, SD=0.65) and integrating evaluators' feedback (M=4.43, SD=0.83), reflecting a commitment to refining their work. Although students were well-prepared for presentations (M=4.26, SD=1.18), their confidence in delivering their research (M=4.18, SD=0.99) was slightly lower, indicating a need for further training in public speaking. Their active role in logistical tasks, such as setting up displays (M=4.43, SD=1.01), underscored their teamwork and collaboration skills.

These results show that science fairs not only engage students in research and innovation but also build skills in communication, teamwork, and self-reflection. Strong participation in coaching highlights the importance of mentorship, while a slight dip in presentation confidence suggests the need for targeted communication training. Overall, the findings affirm science fairs as key platforms for student engagement, innovation, and professional growth. Supporting this, Hund et al. (2018) and C-STEM (2025) emphasized mentorship's role in academic success and innovation, while Ravishankar (2020) stressed the need for public speaking training. Geek Mode Editorial (2024) also highlighted science fairs' impact on fostering scientific inquiry and STEM career interest.

Level of Development of 21st Century Skills Among STEM Students

Table 2
Level of Development of 21st Century Skills Among STEM Students Based on Critical Thinking Skills (n=106)

Indicator	Mean	SD	Verbal Description
1. Understand how knowledge applies to other situations.	4.12	1.07	Highly Developed
2. Identify the essential information needed to answer a science inquiry question.	4.09	1.03	Highly Developed
3. Assess the quality of information thoroughly.	4.24	1.08	Extremely Developed
4. Analyze and synthesize information from multiple sources.	4.19	1.08	Highly Developed
5. Recognize design limitations and consider alternatives.	4.25	1.07	Extremely Developed
6. Develop follow-up questions to expand the inquiry.	4.24	1.09	Extremely Developed
7. Revise drafts with evidence-based justifications.	4.32	0.99	Extremely Developed
8. Reflect on the thinking processes used in scientific inquiry	4.16	1.07	Highly Developed
9. Create follow-up questions to understand client or user needs.	4.27	1.03	Extremely Developed
10. Evaluate reasoning and evidence that support an argument.	4.36	1.05	Extremely Developed
11. Communicate scientific concepts in various formats.	4.20	0.97	Extremely Developed
12. Collaborate effectively with teammates in scientific	4.25	1.17	Extremely Developed

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investigations			
13. Understand driving questions that lead to critical thinking	4.25	1.02	Extremely Developed
14. Gather relevant and sufficient information from diverse sources.	4.33	1.08	Extremely Developed
15. Show curiosity and persistence in scientific inquiry.	4.23	1.08	Extremely Developed
16. Consider different perspectives in scientific investigations.	4.33	0.99	Extremely Developed
17. Justify choices of evaluation criteria.	4.19	1.03	Highly Developed
18. Implement plans effectively during scientific investigations.	4.18	1.05	Highly Developed
19. Manage time and resources efficiently.	4.07	1.10	Highly Developed
20. Uphold ethical standards in scientific investigations.	4.22	1.01	Highly Developed
OVERALL MEAN	**4.22**	**0.94**	**Extremely Developed**

The study found that STEM students exhibit an extremely developed level of critical thinking skills, with an overall mean score of 4.22 (SD=0.94). Students demonstrated strong abilities in evaluating reasoning and evidence (M=4.36, SD=1.05), gathering diverse information (M=4.33, SD=1.08), and considering multiple perspectives (M=4.33, SD=0.99), highlighting their analytical strength and depth in scientific inquiry. They also showed high engagement in recognizing design limitations (M=4.25, SD=1.07), developing follow-up questions (M=4.24, SD=1.09), and synthesizing information (M=4.19, SD=1.08), reflecting their commitment to refining research and deepening understanding.

Strong collaboration skills were evident in their teamwork during investigations (M=4.25, SD=1.17) and in effectively communicating scientific concepts (M=4.20, SD=0.97). Their adherence to ethical standards (M=4.22, SD=1.01) and ability to justify choices using evaluation criteria (M=4.19, SD=1.03) further affirmed their integrity and sound decision-making. While all skills were rated as "Extremely Developed," slight gaps were noted in time and resource management (M=4.07, SD=1.10) and the execution of scientific plans (M=4.18, SD=1.05), suggesting areas for continued growth.

These results confirm that STEM education effectively nurtures critical thinking, analytical reasoning, and teamwork, which are crucial for success in higher education and professional fields. Continued inquiry-based learning and collaborative research will further strengthen these skills.

Du and List (2024) and Amihan and Sanchez (2023) found that evidence-based reasoning improves evaluation skills. Clarke and Davison (2020) emphasized a "researcher perspective" in inquiry, aligning with students' analytical approaches. Sucilestari and Arizona (2020) highlighted inquiry-based learning's role in fostering reflective thinking, while Gómez and Suárez (2020) stressed the importance of evaluating reasoning in scientific understanding. Mayhew (2024) noted that while critical thinking is strong, further support in time management and implementation is needed.

Table 3
Level of Development of 21st Century Skills Among STEM Students Based on Collaboration Skills (n=106)

Indicator	Mean	SD	Verbal Description
1. Create a task list that fairly divides project work among the team.	4.07	1.12	Highly Developed
2. Use time and run meetings efficiently.	4.02	1.03	Highly Developed
3. Involve all team members in tasks.	4.16	1.25	Highly Developed
4. Adapt to changes and reassign tasks when unexpected challenges arise.	4.17	1.16	Highly Developed
5. Acknowledge and respect other perspectives.	4.42	1.14	Extremely Developed
6. Interact with team members effectively.	4.18	1.23	Highly Developed
7. Be polite and kind to my teammates.	4.25	1.20	Extremely Developed
8. Make sure all team members' ideas are equally valued.	4.33	1.20	Extremely Developed
9. Help the team solve problems and manage conflicts.	4.32	1.17	Extremely Developed

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10. Help resolve issues without asking the teacher for help.	3.82	1.26	Highly Developed
11. Complete research to contribute to the team.	4.31	1.21	Extremely Developed
12. Evaluate solutions and help choose the best one.	4.28	1.18	Extremely Developed
13. Assign roles as needed based on team members' strengths.	4.23	1.15	Extremely Developed
14. Follow the rules for team decision-making.	4.30	1.13	Extremely Developed
15. Provide feedback useful to team members.	4.21	1.14	Extremely Developed
16. Assist others when needed and plan team collaboration.	4.29	1.13	Extremely Developed
17. Use agreed-upon technology to manage tasks.	4.25	1.15	Extremely Developed
18. Keep digital files and communication tools organized.	4.36	1.10	Extremely Developed
19. Use shared workspaces for transparent collaboration.	4.27	1.07	Extremely Developed
20. Collaborate with the team in real-time using online tools.	4.18	1.18	Highly Developed
OVERALL MEAN	**4.22**	**1.02**	**Extremely Developed**

The study reveals that STEM students exhibit an extremely developed level of collaboration skills, with an overall mean score of 4.22 (SD=1.02). They consistently demonstrate effective teamwork, characterized by mutual respect, adaptability, shared responsibility, and clear communication. High-performing areas included using agreed-upon technology (M=4.25, SD=1.15), evaluating and choosing solutions (M=4.28,SD=1.18), organizing digital files (M=4.36, SD=1.10), and valuing all team members' ideas (M=4.33, SD=1.20), emphasizing their ability to leverage digital tools and inclusivity in collaboration.

Students also showed strong abilities in conflict resolution (M=4.32, SD=1.17), giving constructive feedback (M=4.21, SD=1.14), and assigning roles based on strengths (M=4.23, SD=1.15). Notably, they excelled in acknowledging diverse perspectives (M=4.42, SD=1.14), a key aspect of fostering innovation and teamwork. Although collaboration skills were highly developed overall, slightly lower scores in real-time digital collaboration (M=4.18, SD=1.18) and fair task division (M=4.07, SD=1.12) suggest room for growth in online teamwork efficiency.

These findings show that STEM students are well-prepared for collaborative professional environments, balancing leadership, problem-solving, and teamwork. Emphasizing structured collaboration and digital teamwork will strengthen these skills. The study highlights STEM education's role in fostering communication and teamwork for research, industry, and interdisciplinary collaboration.

Cherbonnier et al. (2024) and Carvajal, et al. (2025) highlight that digital tools enhance collaboration and critical thinking. The European School Education Platform (2025) emphasizes the importance of collaborative projects for STEM readiness, while Chiangpradit (2023) notes that diverse perspectives improve both understanding and soft skills. Moreover, MITR Learning & Media (2025) advocates for better digital collaboration training to improve real-time coordination and delegation.

Table 4
Level of Development of 21st Century Skills Among STEM Students Based on Communication Skills (n=106)

Indicator	Mean Ratings	SD	Verbal Description
1. Speak clearly and professionally.	4.08	0.98	Highly Developed
2. Answer questions clearly and concisely.	4.02	1.03	Highly Developed
3. Create a clear and interesting introduction and conclusion.	4.09	1.07	Highly Developed
4. Adjust tone, pace, and volume to engage the audience.	4.14	1.06	Highly Developed
5. Use appropriate body language when presenting.	4.14	1.07	Highly Developed
6. Adapt communication style to suit purpose, task, or audience.	4.16	1.05	Highly Developed
7. Maintain appropriate eye contact to engage the	4.18	1.06	Highly Developed

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audience.			
8. Use facial expressions and gestures to reinforce the message.	4.07	1.06	Highly Developed
9. Present all information concisely and logically.	4.10	1.02	Highly Developed
10. Organize information well.	4.09	1.08	Highly Developed
11. Use visuals, charts, or diagrams to enhance written communication.	4.18	1.04	Highly Developed
12. Proofread and revise the research paper for clarity and accuracy.	4.14	1.06	Highly Developed
13. Use digital tools to enhance communication.	4.13	1.05	Highly Developed
14. Use digital platforms effectively for respectful discussions.	4.21	1.01	Extremely Developed
15. Use images, videos, and infographics to strengthen communication.	4.29	1.01	Extremely Developed
16. Use clear language and formatting for accessible digital communication.	4.13	1.10	Highly Developed
17. Modify the communication approach based on audience feedback.	4.19	1.01	Highly Developed
18. Ensure communication fosters understanding and respect.	4.24	1.10	Extremely Developed
19. Actively engage with the audience during presentations.	4.09	1.06	Highly Developed
20. Provide and respond to constructive feedback to improve communication.	4.25	1.04	Extremely Developed
OVERALL MEAN	**4.15**	**0.93**	**Highly Developed**

The study shows that STEM students possess highly developed communication skills, with an overall mean score of 4.15 (SD=0.93). They demonstrate proficiency in expressing ideas clearly, engaging audiences, and effectively using traditional and digital platforms. Top-rated skills include using images, videos, and infographics to enhance communication (M=4.29, SD=1.01), fostering understanding and respect (M=4.24, SD=1.10), and providing responsive feedback (M=4.25, SD=1.04), highlighting their ability to engage audiences and simplify complex information.

Students also excelled in adapting communication based on audience feedback (M=4.19, SD=1.01), engaging during presentations (M=4.09, SD=1.06), and revising work for clarity (M=4.14, SD=1.06), reflecting their awareness of clarity and adaptability. However, slightly lower scores in speaking clearly (M=4.08, SD=0.98), answering concisely (M=4.02, SD=1.03), and using nonverbal cues effectively (M=4.07, SD=1.06) suggest areas for further growth in verbal and nonverbal communication.

The findings indicate that STEM students are well-prepared for academic, research, and professional communication. Continued practice through public speaking, debates, and structured feedback can further enhance their skills. The study emphasizes the importance of integrating communication-focused activities into STEM education to help students master both technical and communication skills.

Supporting literature reinforces these findings. Bosshart (2023), Holland (2024), and Boniforti and Milano (2018) highlight the power of visuals in simplifying information, while Willet et al. (2023), Witteman et al. (2018), and Sanchez, et al. (2022) stress clear communication and mutual respect in collaborative settings. Engerer et al. (2019), and Rivera et al. (2023) value feedback in developing communication skills, and Robinson (2022) advocates for explicit training in verbal and nonverbal techniques.

Table 5
Level of Development of 21st Century Skills Among STEM Students Based on Problem-Solving Skills (n=106)

Indicator	Mean	SD	Verbal Description
1. Identify and define problems that need solutions.	4.17	1.15	Highly Developed
2. Analyze and evaluate the feasibility of proposed solutions.	4.09	1.08	Highly Developed
3. Use logic and evidence to support decisions in problem-	4.14	1.10	Highly Developed

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solving.			
4. Evaluate risks and consequences before implementing solutions.	4.18	1.09	Highly Developed
5. Reflect on the problem-solving process for improvement.	4.20	1.09	Extremely Developed
6. Make adjustments based on feedback and evaluations.	4.22	1.03	Extremely Developed
7. Address cognitive biases during problem-solving.	4.19	1.00	Highly Developed
8. Assess progress and adjust strategies as needed.	4.26	0.99	Extremely Developed
9. Brainstorm multiple potential solutions to problems.	4.30	1.12	Extremely Developed
10. Test and evaluate the outcomes of implemented solutions.	4.16	1.13	Highly Developed
11. Prioritize solutions based on effectiveness and practicality.	4.25	1.11	Extremely Developed
12. Listen to teammates' suggestions and integrate their ideas.	4.29	1.10	Extremely Developed
13. Develop a plan to implement the chosen solution.	4.22	1.09	Extremely Developed
14. Use appropriate tools and techniques for solution execution.	4.22	1.12	Extremely Developed
15. Troubleshoot technical issues during the implementation of the project.	4.18	1.16	Highly Developed
16. Monitor and adjust the implementation process in real time.	4.22	1.13	Extremely Developed
17. Manage stress to maintain clear thinking during problem-solving.	3.99	1.13	Highly Developed
18. Stay motivated and resilient during challenges.	4.12	1.09	Highly Developed
19. Maintain a positive attitude and encourage teammates.	4.16	1.12	Highly Developed
20. Remain open-minded and adapt to changes without frustration.	4.16	1.09	Highly Developed
OVERALL MEAN	**4.19**	**0.99**	**Highly Developed**

The study reveals that STEM students possess highly developed problem-solving skills, reflected in an overall mean score of 4.19 (SD=0.99). They demonstrate strong logical reasoning, critical evaluation, and adaptive strategies essential for academic and real-world challenges. Key strengths include integrating teammates' ideas (M=4.29, SD=1.10), brainstorming multiple solutions (M=4.30, SD=1.12), and documenting their problem-solving process (M=4.20, SD=1.09), showcasing their collaborative and reflective approach.

Students also excel in using logic and evidence (M=4.14, SD=1.10), prioritizing practical solutions (M=4.25, SD=1.11), and troubleshooting technical issues (M=4.18, SD=1.16). Their adaptability (M=4.16, SD=1.09) further highlights resilience in problem-solving, though slightly lower scores in managing stress (M=3.99, SD=1.13) and staying motivated (M=4.12, SD=1.09) suggest the need for additional support in handling pressure.

These findings suggest that STEM students are well-prepared for innovation and complex problem-solving. Continued training through challenging scenarios and stress management can further enhance their resilience. The study emphasizes the importance of experiential learning in STEM education to develop critical thinking, adaptability, and technical skills for future careers.

Supporting research aligns with these results. Chen et al. (2024) and Maslyk (2025) highlight the importance of collaborative problem-solving and adaptability for STEM success. Hall et al. (2022) and Moll Riquelme et al. (2022) stress resilience for overcoming challenges, while Wright et al. (2018) advocate for strengthening adaptability in both educators and students. Fostering critical thinking, resilience, and emotional strength is essential for preparing students for future demands.

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The Relationship Between the Level of Involvement of STEM Students in Science and Technology Fair and Their Overall Level of Development on the 21st-Century Skills

Table 6
Relationship Between the Level of Involvement of STEM Students in Science and Technology Fair and Their Overall Level of Development on the 21st-Century Skills (n=160)

		B	S. E	β	t	p-value
1	(Constant)	-.891	.587		-1.517	.132
	Level of Involvement	1.157	.133	.649	8.710	.000

F (1,104) = 75.868, p = .000[b], R = .649[a], R^2 = .422, ΔR^2 = .416

The results in Table 6 show that STEM students' involvement in the Science and Technology Fair significantly predicts their development of 21st-century skills. A positive regression coefficient (B = 1.157, p = 0.000) and a strong standardized beta (β = 0.649) indicate that higher engagement leads to notable growth in critical thinking, collaboration, communication, and problem-solving skills. The R^2 value of 0.422 shows that 42.2% of the variance in skill development is explained by fair participation, and the high F-value (75.868, p = 0.000) confirms the model's significance.

These findings highlight that participation in research fairs offers valuable experiential learning that enhances students' practical skills beyond the classroom. Educators and policymakers should expand inquiry-driven activities and ensure broader access, especially for under-resourced students.

Supporting research supports these conclusions. Benek and Akçay (2022) found that socio-scientific STEM activities foster creativity, while Wharton (2019) showed that science fairs improve self-efficacy, boosting academic achievement and skill development. These studies emphasize the essentiality of hands-on, discovery-based learning in bridging theory and real-world application, underscoring the need for more student-centered, experiential approaches in STEM curricula to prepare learners for future challenges.

Conclusions

The conclusions of this study are based solely on the results of quantitative statistical analyses conducted on the data gathered from the respondents.

The findings demonstrate that STEM students are highly involved in the Science and Technology Fair, their participation demonstrates their active role in all aspects of the fair, from research preparation to presenting their work and incorporating feedback. Their engagement not only reflects their commitment to the event but also showcases their ability to fully participate in all dimensions of the academic process, further strengthening the fair's importance as an experiential learning tool.

Additionally, the findings confirm that STEM students demonstrate a highly developed level of 21st-century skills, particularly in critical thinking, collaboration, communication, and problem-solving. Their proficiency in these skills reinforces their competence in tackling complex tasks and interacting effectively in team settings, showcasing their readiness for academic and professional challenges in this rapidly advancing society.

The study also highlighted the strong predictive relationship between STEM students' participation in the Science and Technology Fair and their development of 21st-century skills. The positive regression coefficient and substantial R^2 value indicate that STF serves as a powerful avenue for enhancing critical thinking, collaboration, communication and problem-solving. A significant portion of the variance in skill development is attributed to the science fair, reinforcing its importance as an effective platform for cultivating the essential competencies needed for success in STEM fields and beyond.

Recommendations

Given the strong association between STEM students' participation in the Science and Technology Fair and their development of 21st-century skills, it is recommended that schools and organizers continue to enhance such initiatives by integrating hands-on research, interdisciplinary collaboration, and student-led presentations into both curricular and extracurricular programs. Viewing science fairs not merely as competitions but as strategic platforms for skill development can maximize their educational value. STEM teachers are also encouraged to facilitate guided

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reflection and feedback sessions to reinforce critical thinking, communication, collaboration and problem-solving. Future research may explore additional factors that influence these outcomes and examine the long-term impact of science fair participation across different academic tracks.

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