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# EXPLORING THE EFFECTS OF A SHORT-TERM S.T.E.A.M. CARNIVAL ON FEMALE SECONDARY SCHOOL STUDENTS' ATTITUDES AND MOTIVATION TOWARD STEM LEARNING

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## ABSTRACT

Experiential learning is increasingly recognized as a pedagogical approach that bridges theoretical knowledge and practical application in STEM education, contributing to Sustainable Development Goals 4 (Quality Education) and 5 (Gender Equality) by promoting inclusive participation in STEM learning. This study explores female secondary school students' attitudes, motivation, and engagement in STEM learning following participation in hands-on electrical circuit activities conducted during a S.T.E.A.M. Carnival in Malaysia. Grounded in Kolb's Experiential Learning Theory, a mixed-method design involving structured experiential activities and a post-intervention questionnaire was employed. The participants consisted of 15 female secondary school students from diverse academic backgrounds in Malaysia. Descriptive statistics were used to examine students' perceptions of their learning experiences, motivation, and understanding of STEM concepts. The findings suggest that students generally held positive attitudes toward STEM, with personal curiosity and perceived career opportunities identified as the primary motivational factors. A large proportion of students reported a better understanding of physics concepts (93.3%) and greater confidence in scientific problem-solving (86.7%) following participation in the activities. Students also expressed strong preferences for hands-on and collaborative learning approaches, indicating positive perceptions of experiential learning as a means of supporting engagement and self-efficacy. Overall, the findings suggest that short-term experiential STEM interventions are associated with positive self-reported attitudes, motivation, and engagement among participating female students, highlighting the potential of experiential learning to support efforts to reduce gender disparities in STEM engagement. However, the study is limited by its small, female-only sample and reliance on self-reported data, underscoring the need for further research with larger, more diverse populations.



Keywords: experiential learning; STEM education; female students; motivation; attitudes

## INTRODUCTION

STEM education is essential for equipping school students with fundamental knowledge of science and technology, empowering them to tackle global challenges in line with the United Nations Sustainable Development Goals (SDGs), especially SDG 4: Quality Education (Nugroho et al., 2022; Kennedy & Cherry, 2023). The demand for highly skilled STEM workers has made it increasingly important to find effective teaching methods that not only improve students' academic performance but also increase their interest in science-related careers. Despite ongoing educational reforms, many students continue to view STEM courses, especially physics, as abstract, challenging, and unrelated to practical applica-

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tions, resulting in reduced enthusiasm and lower participation in STEM-related pathways (Diquito et al., 2025; Oliveira et al., 2025). This issue has become a growing concern in science education, as students' attitudes and motivation significantly influence their learning outcomes, persistence, and career goals in STEM fields. Furthermore, gender inequality continues to be a global concern, as female students are still underrepresented in STEM education and professions due to factors such as limited participation opportunities, low self-confidence, and persistent gender stereotypes toward science and technology fields (Master et al., 2021). Therefore, strengthening female students' engagement and motivation in STEM learning environments is increasingly important for promoting inclusive and equitable quality education in support of SDG 4 and SDG 5 (Gender Equality).

Recent educational research has emphasized the importance of experiential learning approaches in addressing these challenges. Experiential learning, which includes hands-on activities, project-based learning, collaborative problem-solving, and interactive demonstrations, enables students to construct knowledge actively through direct experience rather than passive information reception (Foss & Liu, 2020; Steele, 2023; U-senyang, 2024). Previous studies have demonstrated that experiential learning can improve students' conceptual understanding, critical thinking skills, and engagement in science education (Khairati et al., 2021; Kong, 2021; Dianita & Tiarani, 2023). Consequently, experiential learning has become an effective strategy to enhance students' participation and confidence in STEM learning environments, while practical learning experiences help learners connect theoretical concepts with real-life situations.

To the best of our knowledge, several gaps remain in existing literature. First, many previous studies have primarily focused on academic achievement and cognitive performance, while paying limited attention to students' affective domains, particularly attitudes, motivation, and future aspirations in STEM education. For instance, most reported STEM and experiential learning activities conducted in schools have focused primarily on assessing students' problem-solving abilities, with greater emphasis on performance than on attitudes and motivation (Afriana et al., 2016; Parno et al., 2021; Lestari, 202 ). Similar trends have also been reported globally, where experiential STEM studies often emphasize measurable academic outcomes while overlooking students' emotional engagement and motivational development (Shahbazloo & Mirzaie, 2023; Shivaramu et al., 2025). Second, although experiential learning has been studied in higher education and formal classrooms, fewer studies have examined the effectiveness of short-term experiential interventions conducted through informal STEM engagement programs such as science carnivals or outreach activities. In addition, limited studies have specifically explored how female secondary school students respond to experiential STEM activities, particularly in physics-related learning environments. Therefore, further empirical investigation is required to support and extend previous findings regarding the educational value of experiential learning in STEM education, especially in promoting inclusive participation and positive learning experiences among female students.

Accordingly, this exploratory case study investigates the impact of experiential learning activities on female secondary school students' attitudes, motivation, and engagement in STEM education, particularly in physics, through participation in a S.T.E.A.M. Carnival program. The novelty of this study lies in its focus on the affective impact of short-term experiential STEM interventions within a secondary school context, particularly through a S.T.E.A.M. Carnival setting that integrates practical physics learning experiences. Unlike many previous studies that primarily emphasized academic performance, this study directly examines students' attitudes, motivation, confidence, and learning preferences following participation in experiential STEM activities. Although the study is limited to a small group of female secondary school students participating in a specific outreach program, the findings provide valuable preliminary evidence on how experiential learning can bridge the gap between theoretical knowledge and practical application. The study is expected to contribute to the development of more inclusive and effective STEM pedagogical strategies that support student engagement, motivation, and quality education in line with SDG 4.

Driven by rapid advances in artificial intelligence, renewable energy, and advanced manufacturing, Malaysia expects strong growth in STEM-related jobs by 2030 (MOSTI, 2025). However, this growth is challenged by a worrying trend: fewer students are enrolling in STEM subjects, and interest in these fields is declining at the secondary school level (Idris et al., 2023). This gap between national demand and student supply highlights the need for education reform. Therefore, it is important to maintain students' motivation and active engagement in STEM to ensure they remain committed and well-prepared for future career paths. The issue of declining student interest is further linked to traditional, lecture-based teaching methods. When learning depends mainly on lectures and memorization, students have fewer opportunities to actively explore ideas or connect what they learn to real-life situations (Eccles & Wigfield, 2020; Kennedy & Cherry, 2023). Consequently, modern pedagogical research highlights the important role of experiential learning (EL) in bridging theoretical knowledge with practical application, which is essential for developing a strong future STEM workforce (Kolb, 2014; Anthony et al., 2021; Hamilton & Margot, 2023; AlAli, 2024; Putri & Dewi, 2025; Agustin et al., 2026).

Among the various learning theories that support active learning, Kolb's Experiential Learning Theory (ELT) provides a particularly relevant framework for STEM education, emphasizing learning through direct experience, reflection, conceptual understanding, and application. According to Kolb (2014), meaningful learning occurs when learners actively engage in a continuous cycle consisting of concrete experience, reflective observation, abstract conceptualization, and active experimentation. As illustrated in Figure 1, this cyclical process encourages students to construct knowledge through authentic experiences rather than passively receiving information.

The relevance of ELT to STEM education is especially significant because many STEM concepts are abstract and difficult for students to connect with everyday experiences. Through hands-on activities, experimentation, and reflective learning, ELT helps students bridge the gap between theoretical concepts and real-world applications while fostering deeper conceptual understanding. Beyond cognitive development, experiential learning also supports affective outcomes by increasing students' motivation, engagement, confidence, and positive attitudes toward STEM disciplines. These outcomes are particularly important for addressing declining interest in STEM education among secondary school students and for encouraging sustained participation in STEM-related pathways. Therefore, Kolb's ELT serves as the theoretical foundation of this study and guides the design of the S.T.E.A.M. Carnival activities, which aim to provide meaningful learning experiences that enhance students' attitudes, motivation, and engagement toward STEM education.

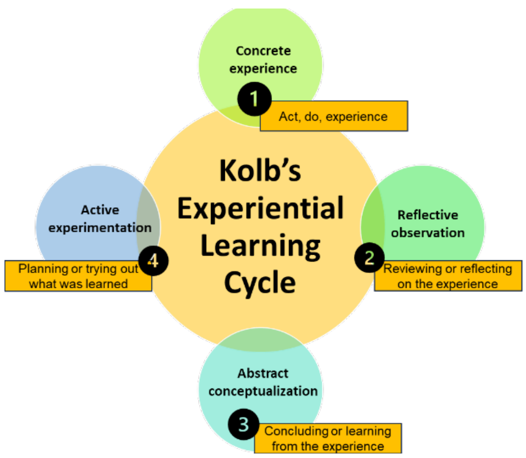


**Figure 1.** Kolb's Experiential Learning Theory (ELT)

Recent studies consistently show that experiential learning (EL) enhances students' understanding and engagement by providing active, real-world experiences that connect theory with practice in STEM education. In addition, EL has been found to have a positive impact on both academic performance and higher-order cognitive skills, including critical thinking and problem-solving.

A synthesis of previous studies related to experiential learning in STEM education is presented in Table 1, which summarizes key authors, research approaches, and main findings. The table highlights a consistent pattern in the literature: most studies report positive effects of experiential and STEM-integrated learning approaches on students' cognitive development, particularly critical thinking and problem-solving skills. In contrast, fewer studies focus specifically on affective outcomes among secondary school learners.

Combining practical exercises with interactive simulations has been shown to significantly improve students' ability to apply theory to new problem-solving situations (Aqlan & Zhao, 2021;

Simanjuntak et al., 2021; Shi et al., 2023). More recent studies further support the effectiveness of experiential learning in STEM education (Ramadhan et al., 2023). They found that blended experiential learning, supported by experimental activities, positively influences both academic achievement and critical thinking skills.

**Table 1.** Summary of recent studies (2021–2026) on the impact of experiential learning in STEM education

| Author (Year) | Learning Approach | Focus Area | Key Findings |
|---|---|---|---|
| (Aqlan & Zhao, 2021; Shi et al., 2023; Simanjuntak et al., 2021) | Practical exercises + interactive simulations | Application of theory | Improves students' ability to apply theory to new problem-solving situations |
| (Ramadhan et al., 2023) | Blended learning with experiments | Academic achievement & critical thinking | Improved both students' critical thinking skills and academic performance |
| (Novitasari et al., 2024) | STEM-based project-based learning | Critical thinking | Develops critical thinking through the investigation of real problems |
| (Rohman et al., 2024) | Ethnoecological-STEM project-based learning | Critical thinking, creativity, and conceptual mastery | Enhances multiple cognitive skills and a deeper understanding |
| (Almujaddid et al., 2025) | STEM + computational thinking experiential learning | Problem-solving | Strengthens problem-solving skills through real-world tasks |
| (Fitriani & Festiyed, 2023; Wijayati et al., 2025) | STEM-integrated project-based learning | Critical thinking & problem-solving | Enhances active learning and application of knowledge |
| (Adhelacahya et al., 2023; Zulfawati et al., 2022) | Problem-based learning + STEM | Critical thinking | Improves critical thinking through analytical and reflective learning |
| (Thibodeaux et al., 2025) | STEM camp (experiential learning) | Attitudes, motivation, career aspiration | Increased students' interest, confidence, and STEM career aspirations |
| (Hiwatig et al., 2024) | Integrated STEM education | Attitudes & motivation | Improved student attitudes, enjoyment, and motivation toward STEM learning |
| (Khaeruddin et al., 2025) | Digital Project-Based Learning | Critical thinking and SDG 4 | Contextual physics learning resources improved critical thinking while supporting Quality Education (SDG 4). |
| (Chin & Chang, 2026) | Project-Based STEM Learning | Communication and collaboration skills | Hands-on STEM projects improved students' communication and collaboration competencies through experiential activities. |
| (Kairi et al., 2024) | Competition-based STEM learning | Motivation & interest | Stimulated student interest and motivation in STEM pathways |
| This study | STEAM Carnival (short-term experiential learning) | Attitudes, motivation, career aspiration | Enhanced students' interest, confidence, and STEM career aspirations |

In addition, Novitasari et al. (2024) reported that STEM-based project-based learning enhances critical thinking by providing students with opportunities to investigate and solve authentic problems, while Rohman et al. (2024) demonstrated that ethnoecological-STEM project-based learning improves critical thinking, creativity, and conceptual mastery. Building on this, Almujaddid et al. (2025) showed that STEM-computational thinking-based experiential learning strengthens students' problem-solving skills through active engagement in real-world tasks, and Fitriani & Festiyed (2023) and Wijayati et al. (2025) further confirmed that STEM-integrated project-based learning enhances both critical thinking and problem-solving abilities through active learning and knowledge application. Most recently, Zulfawati et al. (2022) and Adhelacahya et al. (2023) highlighted that problem-based learning combined with STEM approaches significantly improves critical thinking by engaging students in analytical and reflective learning processes.

Despite growing interest in STEM education, research examining affective outcomes remains relatively limited, particularly regarding how experiential and integrated STEM learning influences students' attitudes, motivation, engagement, and future career aspirations. Nevertheless, existing evidence suggests that these approaches can positively shape students' affective responses toward STEM. For instance, experiential STEM camp experiences have been shown to enhance students' interest, confidence, and aspirations for STEM-related careers (Thibodeaux et al., 2025). Similarly, integrated STEM education has been found to improve students' attitudes, enjoyment, and motivation by providing more engaging and meaningful learning experiences (Hiwatig et al., 2024). Furthermore, project-based and experiential STEM approaches have been reported to foster active participation and engagement in learning. Amri et al. (2024) found that hands-on STEM project activities enhanced students' communication and collaboration skills through active involvement in authentic learning tasks. Likewise, Khaeruddin et al. (2025) demonstrated that contextual physics projects promoted meaningful learning by connecting scientific concepts to real-world situations, thereby increasing students' engagement and interest in STEM learning. Moreover, competition-based STEM activities have also been shown to stimulate students' interest and motivation toward STEM pathways by encouraging challenge-based learning and active participation (Kairi et al., 2024).

Overall, the literature demonstrates that experiential learning contributes positively to both cognitive outcomes, such as academic achievement and critical thinking, and affective outcomes, including students' attitudes, motivation, and engagement in STEM education. However, a closer examination of prior studies reveals that much of this evidence is derived from structured classroom-based interventions, STEM camps, or project-based learning implemented over extended periods. In contrast, less attention has been given to informal, event-based learning environments such as S.T.E.A.M. Carnivals, which integrate short, intensive, and activity-driven STEM experiences within a non-traditional learning setting.

In addition, while previous studies have reported positive affective outcomes in STEM education, there is still limited empirical understanding of how specific hands-on physics activities, particularly those involving fundamental topics such as electrical circuits 99, contribute to students' immediate motivational and attitudinal responses when delivered in a carnival-style experiential learning environment. Furthermore, although affective outcomes have been explored in general STEM contexts, fewer studies have focused specifically on female secondary school students in Malaysia, a group that remains underrepresented in STEM participation and career pathways.

Therefore, this study addresses these gaps by investigating how participation in a S.T.E.A.M. Carnival featuring hands-on electrical circuit activities influences female secondary school students' attitudes, motivation, and engagement toward STEM learning in a Malaysian secondary school context. By focusing on a short-term, informal, and activity-based learning intervention, this study provides context-specific insights into how experiential learning operates in non-traditional STEM engagement settings.

Based on this, the study is guided by the following research questions:

RQ1: What are female secondary school students' attitudes toward STEM learning after participating in a S.T.E.A.M. Carnival?

RQ2: What is the level of students' motivation toward STEM learning following participation in the S.T.E.A.M. Carnival?

RQ3: How do students perceive their engagement and learning experiences during the electrical circuit activities in the S.T.E.A.M. Carnival?

## METHODS

This study employed a mixed-method design to examine students' attitudes, motivation, and learning experiences following participation in experiential learning activities during a S.T.E.A.M. Carnival. The study was guided by Kolb's Experiential Learning Theory (ELT), which emphasizes learning through a cyclical process of concrete experience, reflection, conceptualization, and active experimentation (Kolb, 2014). The experiential activities were designed in alignment with this framework and implemented through hands-on electrical circuit tasks. The research procedure consisted of four stages: preparation, concrete experience, reflective observation, and conceptualization, followed by active experimentation, as illustrated in Figure 2.

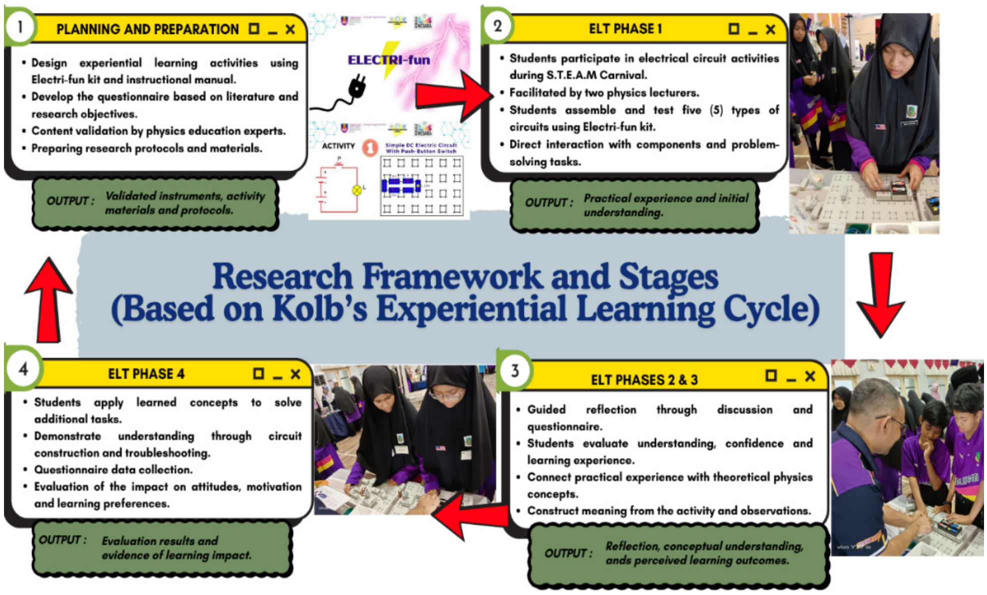


**Figure 2.** Research Framework Illustrating the Application of Experiential Learning in Electrical Circuit Activities during the S.T.E.A.M. Carnival

### Stage 1: Preparation Stage

In the initial stage, the researchers designed the experiential learning activities and prepared the instructional materials using the Electri-fun kit. The questionnaire instrument was also developed based on previous STEM education and motivation studies to ensure alignment with the research objectives. Physics education lecturers reviewed the activities and survey items to ensure content validity and suitability for secondary school students.

### Stage 2: Concrete Experience Stage (Kolb's ELT Phase 1)

Students participated in hands-on electrical circuit activities at the physics booth during the S.T.E.A.M. Carnival at SMKA Sheik Haji Mohd Said. During this stage, students assembled and tested several simple electrical circuits under the guidance of two Physics lecturers from Universiti Teknologi MARA (UiTM) Cawangan Negeri Sembilan Kampus Kuala Pilah. This stage aimed to provide authentic learning experiences through direct interaction with electrical components and practical problem-solving tasks.

### Stage 3: Reflective Observation and Abstract Conceptualization Stage (Kolb's ELT Phases 2 and 3)

After completing the activities, students reflected on their learning experiences through guided discussions and questionnaire responses. Students evaluated their understanding of electrical concepts, their confidence in solving scientific problems, and their perceptions of STEM learning. Through this reflective process, students connected practical experiences with theoretical physics concepts learned in the classroom.

### Stage 4: Active Experimentation and Evaluation Stage (Kolb's ELT Phase 4)

In the final stage, students demonstrated their understanding by applying the learned concepts during additional circuit assembly tasks and problem-solving activities. The effectiveness of the experiential learning intervention was then evaluated using questionnaire data analysis. Students' attitudes, motivation, learning preferences, and future STEM aspirations were analyzed to assess the intervention's educational impact.

The participants were 15 female secondary school students from SMKA Sheik Haji Mohd Said in Malaysia who volunteered for the S.T.E.A.M. Carnival program. The sample included students from Form 1 to Form 5, representing both science and non-science academic streams. Participation was entirely voluntary, and students participated based on their interest and availability during the program activities. Given the small sample size, the single-school setting, and the voluntary nature of participation, the findings of this study should be interpreted as exploratory and context-specific. The results are not intended to be generalized to a broader population, but rather to provide preliminary insights into students' learning experiences and engagement in STEM experiential activities within this particular educational context.

The intervention utilized the Electri-fun kit, which includes basic electrical components such as batteries, switches, wires, bulbs, buzzers, and DC motors. Students engaged in five structured activities involving circuit construction and testing: (1) buzzer circuit, (2) lamp switch circuit, (3) DC motors in parallel, (4) DC motors in series, and (5) push-button circuit. These activities were designed to support conceptual understanding of basic electricity through hands-on experimentation and collaborative learning.

Data were collected using a questionnaire distributed via Google Forms. The instrument consisted of five sections: (A) demographic information, (B) attitudes toward STEM learning, (C) participation experiences, (D) preferred learning approaches, and (E) future STEM aspirations. The questionnaire included 5-point Likert-scale items, multiple-response questions, and open-ended questions to capture both quantitative and qualitative data on students' perceptions and experiences.

The questionnaire was developed based on an adaptation of the Attitude/Motivation Test Battery (AMTB) and relevant STEM education instruments (Gardner, 2005). Content validity was established through expert review involving three physics lecturers from the Department of Physics and Materials Science at the authors' institution. The experts evaluated the instrument on clarity, relevance, appropriateness of language, and alignment with the study objectives and the STEM experiential learning framework. Based on their feedback, several items were refined to improve clarity and contextual suitability for secondary school students, while ambiguous or redundant items were revised accordingly. This process ensured that the instrument had adequate content validity for use in a STEM experiential learning context.

Examples of items from the questionnaire, covering Likert-scale, multiple-response, and open-ended formats, include:
"What motivates you to study science?"
"How fun did you find the STEM activities today?"
"What improvements would you suggest for future STEM activities?"
"What teaching methods do you find most effective for learning science?"

Quantitative data obtained from the questionnaire were analyzed using descriptive statistics. Likert-scale responses were coded and entered into statistical software for analysis. Descriptive statistics, including frequencies and percentages, were computed to summarise students' perceptions of enjoyment, understanding of physics concepts, confidence in problem-solving, and interest in science following participation in the experiential learning activities. The analysis focused on identifying overall trends in students' responses rather than inferential comparisons, as the primary aim was to describe perceived learning outcomes and engagement levels after the intervention. The results were presented in tables and figures to facilitate clear interpretation.

Qualitative data were obtained from open-ended questionnaire items designed to capture students' experiential feedback, including their learning experiences, aspects of the activities they found most engaging, and suggestions for improvement. The qualitative responses were analyzed using thematic analysis following the six-phase approach outlined by Braun and Clarke (2006). To enhance the trustworthiness of the analysis, coding was conducted systematically and reviewed by the researcher to ensure consistency in theme development and interpretation. In addition, the use of direct student responses supported the transparency and credibility of the qualitative findings.

## RESULTS AND DISCUSSION

This section presents and critically discusses the findings from the questionnaire administered after students participated in experiential learning activities during the S.T.E.A.M. Carnival. While the results are organized according to the research objectives, they are also interpreted in light of the study's design limitations, contextual influences, and alternative explanations that may have shaped students' responses.

**Demographic Profile of Respondents**

A total of 15 female secondary school students from SMKA Sheik Haji Mohd Said participated in the study. The majority were Form 4 students (86.7%), followed by Form 3 (6.7%) and Form 1 students (6.7%). Regarding academic background, 60% were from the science stream, while 40% were from non-science streams, as shown in Table 2.

**Table 2.** Demographic Profile of Respondents

| Demographic variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Gender | Female | 15 | 100 |
| Academic Level | Form 1 | 1 | 6.7 |
| | Form 3 | 1 | 6.7 |
| | Form 4 | 13 | 86.7 |
| Academic Stream | Science | 9 | 60.0 |
| | Non-Science | 6 | 40.0 |

This variation suggests differences in prior STEM learning experience, which may influence students' engagement and responses in experiential learning environments. Recent research indicates that prior academic experience and STEM background can significantly shape students' engagement, confidence, and conceptual understanding in hands-on science activities (DeWitt et al., 2016; Stephenson et al., 2022).

Studies on informal and experiential STEM learning environments show that students from diverse academic backgrounds may engage differently with hands-on learning, particularly in terms of curiosity, participation, and conceptual development. For example, meta-analytic evidence suggests that informal STEM learning experiences, such as outreach programs and science fairs, positively affect students' attitudes and engagement in science, especially when learning is active and inquiry-based (Roberts et al., 2018; Xia et al., 2025). Similarly, active learning environments have been shown to improve student engagement and achievement in STEM disciplines compared to traditional lecture-based approaches (Roig et al., 2026).

The exclusive focus on female students is also important given persistent gender disparities in STEM participation. Although research shows that experiential STEM activities can support girls' engagement and interest, gender differences in STEM identity, confidence, and self-efficacy remain evident during secondary schooling (Cohen et al., 2021; Master, 2021). Recent studies further emphasize that inclusive, collaborative, and context-based STEM learning environments are particularly effective in supporting female students' participation and reducing gender-based disparities in engagement (Kim et al., 2018; Al-Hinai et al., 2026).

**Female Students' Attitudes Toward STEM Learning (RQ1)**

The findings indicate that participation in the S.T.E.A.M. Carnival fostered generally positive attitudes toward STEM learning among female secondary school students. As presented in Figure 3, personal curiosity emerged as the strongest factor influencing students' interest in STEM (66.7%, n = 10), followed by career opportunities (53.3%, n = 8), placement in science-stream classes (46.7%, n = 7), and encouragement from teachers and family members (33.3%, n = 5). This pattern suggests that intrinsic factors, particularly curiosity, played a more prominent role than external influences in shaping students' attitudes toward STEM following the carnival experience.

The dominance of curiosity supports motivational and contextual learning theories, which posit that intrinsic factors are more effective in sustaining engagement because they are closely linked to autonomy and situational interest (Vongkulluksn et al., 2018). Likewise, the influence of career opportunities aligns with expectancy-value theory, which posits that students are more motivated to engage in learning when they perceive STEM disciplines as useful and relevant to their future aspirations (Ball et al., 2016). The moderate influence of science-stream placement suggests that structural exposure alone may not be sufficient to cultivate positive attitudes unless accompanied by meaningful and authentic learning experiences. This finding is consistent with research highlighting the importance of contextualized and experiential STEM learning in strengthening student engagement and interest, particularly when learning activities are meaningful and authentic (Roberts et al., 2018; Xia et al., 2025).

The comparatively lower influence of teacher and family encouragement further indicates that social persuasion may not necessarily translate into internalized interest in STEM without opportunities for active inquiry and personal exploration. Overall, the findings suggest that the S.T.E.A.M. Carnival positively influenced female students' attitudes toward STEM by stimulating curiosity and increasing awareness of STEM's potential value for future educational and career pathways.

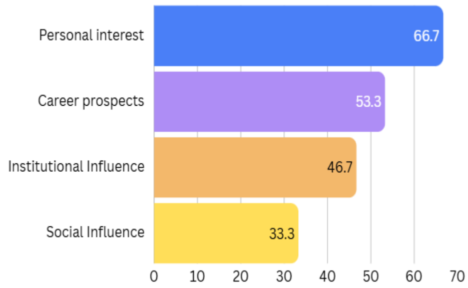


**Figure 3.** Factors Influencing Students' Interest in STEM Subjects

**Students' Motivation Toward STEM Learning Following the S.T.E.A.M. Carnival (RQ2)**

The findings indicate that students demonstrated a moderately high level of motivation toward STEM learning following participation in the S.T.E.A.M. Carnival. Students reported high levels of enjoyment during the experiential activities, with 73.3% (n =11) rating their enjoyment between 4 and 5 on a five-point scale, as illustrated in Figure 4, suggesting that the carnival experience successfully stimulated positive motivational responses toward STEM learning. The positive motivational outcomes can be explained by the experiential nature of the activities, particularly the opportunity to construct electrical circuits with the Electri-fun kit actively.

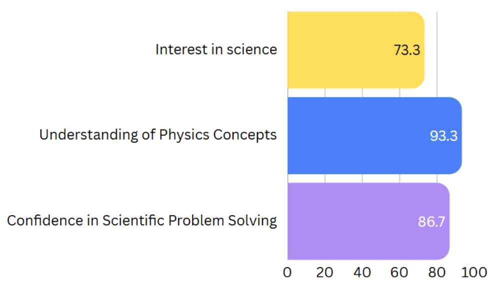


**Figure 4.** Students' Perceived Impact of STEM Activities on Motivation

Experiential learning theory emphasizes that meaningful learning occurs through concrete experiences, active experimentation, and reflective engagement, all of which contribute to increased interest and motivation. The hands-on activities likely provided students with immediate feedback and a sense of accomplishment, thereby reinforcing their enjoyment and willingness to engage with STEM concepts.

Nevertheless, the findings also indicate that motivation may not be fully sustained beyond the immediate learning context. Although the majority of students reported positive interest and enjoyment, approximately one-quarter did not report high levels of interest. This discrepancy suggests that while experiential activities can generate situational motivation, longer-term motivational development may require repeated exposure, sustained engagement, and stronger connections between STEM learning and students' personal goals and future aspirations. Similar findings have been reported in previous studies, which demonstrate that experiential STEM activities effectively enhance short-term motivation and interest but require continued reinforcement to produce enduring motivational changes (Gossen & Ivey, 2023).

**Table 3.** Students' Future Aspirations Toward STEM Careers

| Career Aspiration | Frequency (n) | Percentage (%) |
|---|---|---|
| Interested in a STEM-related career | 9 | 60.0 |
| Undecided | 5 | 33.3 |
| Not interested | 1 | 6.7 |

Additionally, students' future aspirations further reflect their motivational orientation toward STEM. 60% of respondents (n =9) expressed interest in pursuing STEM-related careers, while 33.3% (n = 5) remained undecided, as presented in Table 3. Moreover, 73.3% agreed that science and technology play important roles in their daily lives and future development. These findings suggest that participation in the carnival not only increased students' immediate motivation but also strengthened their recognition of STEM's relevance and value in future educational and career contexts. Overall, the findings indicate that the S.T.E.A.M. Carnival generated moderately high motivation for STEM learning by promoting enjoyment, interest, and appreciation for the relevance of science and technology. However, sustaining this motivation may require continuous exposure to meaningful and authentic STEM experiences beyond a single intervention.

**Students' Engagement and Learning Experiences During Electrical Circuit Activities (RQ3)**

All respondents participated in the electrical circuit activities at the physics booth, where they constructed electrical circuits using the Electri-fun kit. The findings demonstrate highly positive perceptions of engagement and learning experiences during these activities. In terms of perceived learning outcomes, a large majority of students (93.3%) reported that the activities enhanced their understanding of fundamental physics concepts, particularly simple electrical circuits, while 86.7% indicated increased confidence in solving scientific problems, as shown in Figure 4.

The qualitative feedback further supports these findings. Students commonly described the activities as enjoyable, interactive, and helpful in making abstract physics concepts easier to understand. Several respondents also suggested incorporating additional collaborative activities between schools, increasing the use of gamified elements, such as science riddles, and providing more hands-on experiments and science models. These suggestions indicate that students valued active, collaborative, and varied learning experiences.

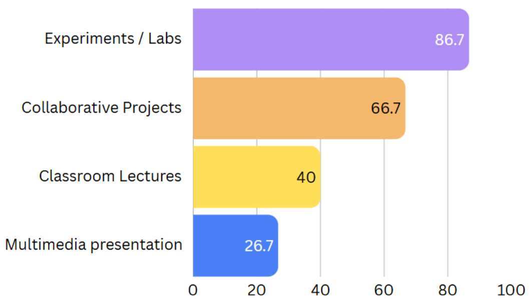


**Figure 5.** Students' Preferences for Teaching Methods

Students' preferences for instructional approaches similarly reflected their positive engagement with experiential learning. As shown in Figure 5, the majority of respondents preferred hands-on experiments (86.7%, n = 13), while 66.7% (n = 10) preferred collaborative group projects over traditional lecture-based instruction. Although 53.3% perceived school science lessons as engaging, nearly half of the respondents expressed neutral or less favorable perceptions, suggesting that conventional classroom instruction may not consistently provide the level of engagement experienced during the carnival activities.

These findings are consistent with previous STEM education research demonstrating that active learning strategies significantly enhance student engagement, conceptual understanding, and knowledge retention (Stanberry & Payne, 2018; Cottafava et al., 2019; Theobald et al., 2020). Furthermore, experiential and collaborative learning approaches have been shown to promote critical thinking, self-efficacy, motivation, and meaningful participation in science learning (Kusumoto, 2018; Andayani & Gunawan, 2025). The findings also support experiential learning theory, which emphasizes the importance of concrete experiences and active participation in facilitating deeper understanding and more meaningful learning.

Overall, the electrical circuit activities provided highly positive and engaging learning experiences for the participants. The integration of hands-on experimentation, collaborative learning, and real-world application enabled students to develop conceptual understanding and confidence while fostering meaningful engagement with physics concepts. These findings highlight the value of experiential, student-centered pedagogical approaches in promoting effective STEM learning experiences among female secondary school students.

Furthermore, students expressed stronger preferences for active, hands-on, and collaborative learning approaches than for traditional lecture-based instruction. Nevertheless, the findings should be interpreted cautiously. Although students generally reported positive attitudes and experiences, only slightly more than half of the participants expressed a high level of interest in science during the activities, suggesting that positive perceptions did not uniformly translate into strong affective engagement among all students. This suggests that students' responses to short-term experiential STEM activities may be varied and that multiple factors beyond participation in a single intervention likely influence interest development.

This study contributes to the STEM education literature by providing exploratory evidence regarding female students' perceptions of STEM learning in an informal, experiential setting. Rather than demonstrating that experiential learning directly improves attitudes or motivation, the findings suggest that such activities may offer students opportunities to engage with STEM in ways they perceive as relevant, interactive, and engaging. Given the absence of baseline measurements and a comparison group, no causal inferences can be made regarding the effects of the S.T.E.A.M. Carnival on students' attitudes or motivation.

The study is limited by its small, gender-specific sample and reliance on self-reported data collected immediately after the intervention. Consequently, the findings should be considered preliminary and interpreted within the specific context of this study. Future research should employ larger samples, pre- and post-intervention designs, comparison groups, and mixed-method or longitudinal approaches to examine whether repeated experiential STEM activities contribute to sustained changes in students' engagement, motivation, STEM identity, and academic outcomes over time.

## CONCLUSION

This study provides preliminary insights into the attitudes, motivation, engagement, learning experiences, and future aspirations of 15 female secondary school students following their participation in a S.T.E.A.M. Carnival. Overall, the findings indicate that students generally reported positive perceptions of STEM learning and viewed the experiential activities as enjoyable, engaging, and helpful for understanding scientific concepts, particularly simple electrical circuits. Many participants also reported increased confidence in problem-solving and recognized the importance of science and technology in their daily lives and future careers. However, these findings are based solely on self-reported perceptions and do not reflect objectively measured learning gains or the intervention's causal effects. The results also suggest that personal curiosity and perceived career opportunities were important factors associated with students' interest in STEM.

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