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WINNING STEM INNOVATION THROUGH ENTREPRENEURSHIP: A CASE STUDY

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ABSTRACT

STEM competitions serve as a platform for students to apply scientific and technological knowledge in real-world problem-solving. This study examines the key success factors of a winning STEM innovation, focusing on a secondary school team that developed Carissa Carandas Natural Lip Balm. The team won gold medals at the Bangkok International Intellectual Property, Invention, Innovation and Technology Exposition (IPITEx) 2025 in Thailand and the Malaysia Technology Expo (MTE) 2025, two of the most prestigious innovation exhibitions in their respective countries. Through a qualitative case study approach, this research analyzes the innovation process, challenges faced, and the impact of mentorship and commercialization strategies. Findings indicate that a combination of scientific research, entrepreneurial integration, and strong mentorship from school and university-level experts significantly contributed to their success. A key distinguishing factor was the team's decision to sell their product at both exhibitions, proving its market readiness and commercial viability. The study highlights the importance of integrating entrepreneurial elements into STEM education, providing students with both technical expertise and business acumen. These findings offer valuable insights for educators, competition organizers, and policymakers in enhancing STEM innovation frameworks.

Keywords: STEM innovation, entrepreneurship, STEM competitions, project-based learning, Carissa Carandas Lip Balm

Introduction

Background

STEM (Science, Technology, Engineering, and Mathematics) innovation is essential in preparing students for the demands of the modern workforce and fostering problem-solving, creativity, and critical thinking skills. As the world increasingly relies on technology and scientific advancements, equipping students with STEM competencies ensures their ability to contribute to future innovations.

One of the most effective ways to nurture STEM skills is through competitions, which provide hands-on experience and encourage students to apply theoretical knowledge in real-world scenarios. Research highlights those competitions such as robotics challenges and science fairs enhance students' technical and soft skills, including teamwork, communication, and problem-solving (Zhang et al. 2022). Moreover, early exposure to STEM competitions has been linked to increased interest in STEM careers, with students who actively engage in such activities being more likely to pursue STEM degrees (Bottía et al. 2017).

Beyond technical expertise, STEM competitions play a pivotal role in shaping students' confidence and motivation. Studies indicate that participation in competitive STEM events fosters

collaboration, networking, and resilience—traits crucial for professional success (Chatzis, Papasalouros, and Kavallieratou 2022). Furthermore, competitions help develop positive attitudes toward STEM subjects, which can lead to greater persistence in STEM education (Welch 2010). Given the increasing emphasis on STEM education globally, understanding the factors that contribute to success in STEM competitions is vital for educators, students, and policymakers.

This study explores the factors contributing to win a STEM innovation in an innovation competition, focusing on the challenges faced, strategies employed, and the broader impact of the competition experience.

Problem Statement

Despite the growing emphasis on STEM education, there is limited research on what distinguishes successful STEM innovations in competitive settings. While many students participate in STEM competitions, not all achieve recognition, raising questions about the key factors that contribute to winning projects. Additionally, challenges such as resource limitations, mentorship availability, and team dynamics can influence competition outcomes. Understanding these elements can provide valuable insights for students, educators, and organizers to enhance future STEM education initiatives.

Research Objectives

This study aims to:

1. Examine the key factors contributing to a winning STEM innovation in an innovation competition.
2. Analyze the challenges faced by students during the innovation process.
3. Explore the impact of STEM competitions on students' skills, motivation, and career aspirations

Literature Review

Benefits of Stem Competitions in Student Learning

STEM competitions offer numerous benefits for student learning, significantly enhancing their educational experiences and skill sets. These competitions provide a platform for students to apply theoretical knowledge in practical scenarios, develop critical soft skills, and foster a deeper interest in STEM fields. This synthesis discusses the various advantages of STEM competitions in promoting student learning.

One of the most notable benefits of STEM competitions is the opportunity for hands-on learning. According to Zhang et al., competitions such as the World Robot Olympiad allow students to engage in project-based learning, where they can apply their knowledge of robotics in real-world contexts (Zhang et al. 2022). This experiential learning not only cultivates students' innovative spirit

but also enhances their practical abilities, leading to a more profound understanding of STEM concepts. Such competitions create an environment where students can experiment, fail, and learn from their mistakes, which is crucial for developing resilience and problem-solving skills (Zhang et al. 2022).

In addition to practical skills, STEM competitions significantly contribute to the development of essential soft skills. Brown emphasizes that participation in STEM competitions helps students cultivate critical thinking, collaboration, and communication skills, which are vital for success in the modern workforce (Brown 2024). These competitions often require students to work in teams, fostering collaboration and teamwork. As noted by Chung, competitions like Robofest encourage students to develop leadership, creativity, and problem-solving skills in a playful learning environment (Chung 2019). This combination of technical and soft skills prepares students for future challenges in their academic and professional careers.

Moreover, STEM competitions can enhance students' motivation and interest in STEM subjects. Wai et al. found that early exposure to STEM activities, including competitions, significantly influences students' decisions to pursue STEM majors in higher education (Wai et al. 2010). The excitement and engagement generated by competitions can spark a lasting interest in STEM fields, encouraging students to explore these areas further. This is particularly important in an era where there is a growing demand for skilled professionals in STEM industries.

Furthermore, STEM competitions can serve as a critical pathway for underrepresented groups in STEM. By providing equitable access to engaging STEM experiences, competitions can help bridge the gap for students from diverse backgrounds. Friedensen et al. highlight the role of family support in developing STEM aspirations among students with disabilities, indicating that competitions can provide additional motivation and resources for these students (Friedensen et al. 2022). By fostering an inclusive environment, STEM competitions can empower all students to pursue their interests in science, technology, engineering, and mathematics.

Key Success Factors in Stem Projects

The success of STEM projects is influenced by various critical success factors (CSFs) that can enhance student engagement, learning outcomes, and overall project effectiveness. Understanding these factors is essential for educators and program coordinators to design and implement successful STEM initiatives. This synthesis highlights key success factors that contribute to the effectiveness of STEM projects.

One of the primary success factors is the presence of mentorship and support systems. Kricorian et al. emphasize that matched mentors can significantly influence the participation of underrepresented students in STEM fields (Kricorian et al. 2020). Mentorship not only provides guidance and encouragement but also helps students develop the necessary mindsets for success in STEM disciplines.

Family support is also crucial, as positive reinforcement from family members can enhance students' social and cultural capital, which is vital for educational achievement (Kricorian et al. 2020). This underscores the importance of creating a supportive environment that fosters student confidence and motivation.

Another critical factor is the quality of educational resources and training programs. Gavrilas and Kotsis argue that the successful integration of educational robotics into STEM education requires a focus on fundamental STEM principles rather than merely presenting activities with robotics kits (Gavrilas and Kotsis 2024). This suggests that well-designed training programs that emphasize core STEM concepts can lead to more effective learning experiences. Additionally, the professional development of educators is essential to ensure they are equipped to deliver high-quality STEM instruction. Hrynevych et al. highlight that the professional level of teachers and the quality of educational support are pivotal for the success of STEM education (Hrynevych et al. 2022).

Collaboration and teamwork are also vital components of successful STEM projects. Projects that encourage collaborative learning allow students to develop essential soft skills, such as communication and problem-solving abilities. Ubaid highlights that organizations that foster a collaborative culture tend to achieve better performance outcomes (Ubaid 2023). In the context of STEM education, fostering teamwork can enhance students' learning experiences and prepare them for future collaborative work environments.

Moreover, the alignment of project goals with students' interests and real-world applications is crucial. Projects that connect STEM concepts to real-life problems can significantly enhance student engagement and motivation. However, the reference provided does not directly support this claim, so it has been removed. When students see the practical implications of their work, they are more likely to invest effort and creativity into their projects.

Finally, continuous assessment and feedback mechanisms are essential for the success of STEM projects. Regular evaluations can help identify areas for improvement and ensure that projects remain aligned with educational goals. Khan et al. emphasize that organizations that prioritize critical success factors and allocate resources effectively tend to achieve better outcomes (Khan et al. 2021). In STEM education, this means implementing feedback loops that allow students to reflect on their learning and make necessary adjustments throughout the project lifecycle.

Methodology

Research Design

This study employs a qualitative case study approach to explore the key factors contributing to the success of a winning STEM innovation. The case study focuses on a secondary school team that developed the Carissa Carandas Natural Lip Balm, an award-winning product that secured gold medals

at both national and international competitions. The study aims to analyze the team's innovation process, challenges faced, and the impact of their competition success.

Participants

The study involves a team of five secondary school students, along with one school teacher and two university mentors from UiTM, who guided the students throughout the competition journey. This diverse group provides insights into the collaboration between school and university-level mentoring in STEM innovation.

Data Collection Methods

To gain an in-depth understanding of the innovation process, the study utilizes multiple qualitative data collection methods:

1. Document Analysis
    - Review of competition reports, judges' feedback, and media coverage related to the Carissa Carandas Natural Lip Balm innovation.
    - Examination of the team's project proposal, presentation materials, and scientific documentation.
2. Observations & Reflections
    - Analysis of team interactions, decision-making processes, and problem-solving approaches based on retrospective reflections from the participants.

Data Analysis

A thematic analysis approach will be used to identify key themes emerging from the collected data. Data will be categorized based on:

1. Innovation Process: How the team developed their idea, refined their product, and prepared for the competition.
2. Challenges & Solutions: Obstacles faced, and strategies used to overcome them.
3. Mentorship & Collaboration: The role of school and university mentors in shaping the innovation.
4. Competition Impact: How participation influenced students' skills, confidence, and future aspirations in STEM.

Findings and Discussion

Innovation Process of Carissa Carandas Natural Lip Balm

The development of the Carissa Carandas Natural Lip Balm followed a structured innovation process, demonstrating the students' ability to integrate scientific research, product development, and entrepreneurship. The process included:

- Problem Identification: The team recognized a gap in the market for natural, locally sourced lip care products.
- Scientific Research: They investigated the benefits of *Carissa carandas* (Karanda) fruit, known for its antioxidant and moisturizing properties.
- Product Formulation & Testing: The team refined the lip balm's composition through multiple trials, ensuring stability, texture, and effectiveness.
- Packaging & Branding: A strong visual identity was created to enhance market appeal, making the product suitable for commercialization.

Their approach aligned with project-based learning (PBL), which fosters problem-solving, teamwork, and creativity—key elements for success in STEM innovation (Erdoğan et al. 2016)

Factors Contributing to Competition Success

The Carissa Carandas Natural Lip Balm secured gold medals at both the Bangkok International Intellectual Property, Invention, Innovation and Technology Exposition (IPITEx) 2025 in Thailand and the Malaysia Technology Expo (MTE) 2025. These are among the most prestigious innovation exhibitions in their respective countries, attracting top innovators and researchers worldwide. Several factors contributed to the team's outstanding performance:

Strong Mentorship and Collaboration

Guidance from a school teacher and two UiTM mentors played a critical role in refining the product and ensuring it met competition standards. The university mentors provided insights on scientific validation and commercial potential, while the school teacher facilitated team coordination and presentation skills. This reflects research suggesting that mentorship significantly enhances students' innovation outcomes in STEM competitions (Peters-Burton et al. 2019).

Commercial Viability of the Product

Unlike many participants who showcased only prototypes, the team took a unique approach by selling the lip balm directly at both exhibitions. This demonstrated the product's market readiness, setting them apart from other competitors. Judges recognized the real-world impact and commercial potential of their innovation, which strongly influenced their gold medal wins. Research suggests that STEM projects

integrating entrepreneurial elements tend to receive higher recognition due to their tangible impact (Welch 2010).

Effective Presentation and Marketing Strategy

The team excelled in presenting their innovation through a well-structured pitch, engaging product demonstrations, and compelling branding. Their ability to articulate the scientific basis, sustainability aspects, and consumer benefits of their lip balm further strengthened their position in the competition.

Challenges Faced and Solutions Implemented

Despite their success, the team encountered several obstacles throughout their innovation journey:

- Limited Access to Laboratory Resources

  As secondary school students, they lacked access to advanced testing facilities. Collaboration with UiTM mentors allowed them to conduct necessary experiments and improve product quality.
- Balancing Academic Responsibilities

  Managing schoolwork alongside intensive competition preparation was challenging. The team adopted a structured work plan with assigned roles to ensure efficiency.
- Product Quality and Consistency

  Ensuring uniform texture and stability in the lip balm required multiple refinements. They achieved a final product that met industry standards by systematically adjusting ingredient ratios and testing different formulations.

Impact of STEM Innovation and Competition Participation

Participation in IPITEx and MTE 2025 had a profound impact on the students, providing them with valuable STEM and entrepreneurial experiences:

- Hands-On STEM Learning: The project deepened their understanding of scientific research, formulation techniques, and product development.
- Entrepreneurial Mindset: Selling their product at the exhibitions helped them develop marketing, financial, and business skills.
- Career Aspirations in STEM: Exposure to an international innovation ecosystem inspired students to explore future careers in science, technology, and business.
- Confidence and Teamwork: The experience of competing at a high level strengthened their communication, collaboration, and leadership skills.

These findings align with research highlighting the role of STEM competitions in fostering innovation, real-world problem-solving, and career motivation among students (Mohr-Schroeder et al. 2014).

Conclusion and Recommendations

Conclusion

The success of the Carissa Carandas Natural Lip Balm in securing gold medals at IPITEx 2025 in Thailand and MTE 2025 in Malaysia underscores the significant role of STEM innovation in shaping students' problem-solving abilities, entrepreneurial mindset, and scientific research skills. This case study highlights how a well-structured approach to STEM education, supported by strong mentorship and real-world application, can lead to remarkable achievements in innovation competitions.

The students demonstrated an impressive ability to integrate scientific knowledge into product development, ensuring that their lip balm was not only scientifically validated but also commercially viable. Their participation in these competitions was strengthened by the guidance of their school teacher and university mentors, who provided critical insights into research methodology and product refinement. A key factor that set them apart from other competitors was their decision to sell their lip balm during the exhibitions, proving its market readiness and commercial potential. This entrepreneurial approach, combined with a strong research foundation and effective presentation skills, contributed to their outstanding performance in both competitions.

Beyond their competition success, the experience provided the students with invaluable exposure to the broader STEM and business ecosystems. It allowed them to develop skills in scientific research, innovation, teamwork, business strategy, and communication, all of which are essential for future careers in STEM fields. This case study reinforces the importance of providing students with opportunities to apply their STEM knowledge in practical settings, preparing them for real-world challenges and fostering a culture of innovation.

Recommendations

To further enhance STEM innovation among high school students, there is a need to encourage innovation competitions that integrate both scientific research and entrepreneurial elements. Competitions should emphasize not only the development of prototypes but also the commercialization potential of student innovations. Providing students with the opportunity to market and sell their products within the competition framework can help them understand the business aspects of STEM innovation, making their projects more impactful.

Another crucial factor in the success of student innovators is mentorship and collaboration with universities and industry experts. Strengthening the connection between secondary schools and higher

education institutions can provide students with access to advanced research facilities, expert guidance, and industry insights that enhance the quality and feasibility of their projects. Partnerships between schools, universities, and private industries can create a supportive ecosystem that nurtures young innovators and ensures they receive the necessary technical and business mentorship.

Incorporating project-based learning (PBL) approaches into STEM curricula is essential to fostering an innovative mindset among students. Schools should prioritize hands-on learning experiences where students are encouraged to develop real-world solutions using STEM concepts. By integrating problem-solving and critical thinking activities into the classroom, educators can better prepare students for innovation challenges at both national and international levels.

Funding and resource allocation also play a pivotal role in enabling students to develop high-quality innovations. Governments, private organizations, and academic institutions should offer financial grants, incubation programs, and sponsorships to support young innovators in prototyping, testing, and refining their products. These financial and logistical resources would allow students to fully explore their creative potential and enhance the viability of their projects.

Finally, increasing student participation in international STEM exhibitions and competitions can broaden their perspectives and expose them to global innovation trends. Schools should actively seek opportunities for their students to compete in prestigious platforms like IPITEx and MTE, as these events provide invaluable networking experiences, knowledge exchange, and recognition for young innovators. Engaging in these competitions not only enhances students' confidence but also motivates them to pursue STEM careers with a global outlook.

By implementing these recommendations, educators, policymakers, and industry leaders can create a sustainable STEM innovation ecosystem that empowers students to develop scientific, technological, and entrepreneurial competencies. Encouraging young innovators to engage in real-world problem-solving will help shape a generation of future STEM leaders, researchers, and entrepreneurs, contributing to national and global advancements in science and technology.

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