Full paper

Sains Humanika

Competition-Based Learning in Science Camp to Stimulate Upper Secondary School Students' Motivation in Learning STEM

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Abstract

This paper introduces a study on the implementation of science, technology, engineering, and mathematics (STEM)-related modules in a science camp to stimulate the interest and motivation of students in learning STEM. The study shows the decision taken by a student to pursue STEM in Tertiary education can be influenced by the people around them and the exposure provided during the high school years. The implementation of robust STEM education would help to combat the change at the age where students will seek their future direction. The incorporation of competition-based learning and experiential learning, combined with the other classical and active learning techniques, have motivated the students and indirectly sparked their interest in STEM. Five unique STEM-related modules have been incorporated into this 3-day and 2-night science camp, which consists of 72 upper-secondary school students from seven selected boarding schools around Malaysia. The purpose of the science camp is to provide exposure for the students to understand the significance of STEM, cultivate a culture of innovation, and indirectly boost motivation among the students. The experience gained is summarized from the analysis of the survey via qualitative and quantitative means. Positive survey results, where 96% are now pursuing their tertiary education in the field of STEM, suggest that students are directly influenced and motivated by the use of competition in the STEM modules to collaboratively appreciate the beauty of STEM education while learning it together with a mission to win the competition.

Keywords: Experiential learning, STEM, science camp, students' motivation, informal learning, competition-based learning

Abstrak

Kertas kerja ini memperkenalkan kajian tentang pelaksanaan modul berkaitan sains, teknologi, kejuruteraan, dan matematik (STEM) dalam kem sains untuk merangsang minat dan motivasi pelajar dalam mempelajari STEM. Kajian menunjukkan keputusan yang diambil oleh pelajar untuk mengikuti STEM dalam pendidikan tertiari boleh dipengaruhi oleh orang di sekeliling mereka dan pendedahan yang diberikan semasa sekolah menengah. Pelaksanaan pendidikan STEM yang mantap akan membantu untuk memerangi perubahan pada usia di mana pelajar akan mencari hala tuju masa depan mereka. Penggabungan pembelajaran berasaskan persaingan dan pembelajaran berasaskan pengalaman, digabungkan dengan teknik pembelajaran klasik dan aktif yang lain, telah memotivasikan pelajar dan secara tidak langsung mencetuskan minat mereka terhadap STEM. Lima modul unik berkaitan STEM telah dimasukkan ke dalam kem sains 3 hari 2 malam ini, yang terdiri daripada 72 pelajar sekolah menengah atas dari tujuh sekolah berasrama penuh terpilih di seluruh Malaysia. Tujuan kem sains diadakan adalah untuk memberi pendedahan kepada pelajar untuk memahami kepentingan STEM, memupuk budaya inovasi, dan secara tidak langsung meningkatkan motivasi dalam kalangan pelajar. Pengalaman yang diperolehi diringkaskan daripada analisis tinjauan melalui kaedah kualitatif dan kuantitatif. Keputusan tinjauan yang positif, di mana 96% kini melanjutkan pengajian tinggi mereka dalam bidang STEM, mencadangkan bahawa pelajar secara langsung dipengaruhi dan bermotivasi dengan penggunaan persaingan dalam modul STEM untuk menghargai keindahan pendidikan STEM secara kolaboratif sambil mempelajarinya bersama-sama dengan misi untuk memenangi pertandingan.

Kata kunci: pembelajaran melalui pengalaman, STEM, kem sains, motivasi pelajar, pembelajaran tidak formal, pembelajaran berasaskan persaingan

■1.0 INTRODUCTION

Concerns over pupils' waning interest in STEM education have been voiced extensively in Malaysia. Attention includes the national concern about the nation's ability to compete in the global economy, referring to the effort in strengthening the STEM pipeline (Nas, 2005), so it will spark interest in STEM education. The pipeline includes various initiatives for school students to be introduced to STEM, both formally and informally, to further sharpen the STEM education landscape in Malaysia. Part of it is the introduction of STEM modules outside the classroom so the students can be exposed to the hands-on activities and application of the STEM-related modules.

An educational strategy known as experiential learning places a strong emphasis on learning via hands-on application and active participation in the curriculum. Through experimentation, reflection, and real-world application, students are encouraged to learn through experiential learning as opposed to merely depending on traditional lecture and theoretical knowledge alone. This method seeks to improve comprehension, critical thinking, problem-solving abilities, and knowledge retention. All things considered, experiential learning provides a comprehensive and dynamic approach to teaching that empowers students to take an active role in their education and acquire skills necessary for success in a variety of spheres of life. One type of experiential learning is science camp, where students have a deeper understanding and connection to the subjects being taught through this method of understanding and internalizing concepts.

The most common framework for experiential learning comes to us through the work of David Kolb. Kolb's Experiential Learning Cycle comes in four stages: concrete experience (direct engagement), reflective observation (reflection on the experience), abstract conceptualization (creation of theories and understanding), and active experimentation (practical application of knowledge) (Kolb, 2017). This model emphasizes a continuous, iterative learning process where individuals engage in real experiences, reflect on them, extract abstract concepts, and apply their newfound knowledge. This study's foundation is the widespread use of it in professional development and education to encourage experiential learning and a deeper comprehension of the material through reflection and personal experience.

The decline in students' interest in pursuing STEM (Science, Technology, Engineering, and Mathematics) education is a pressing concern with far-reaching implications for educational systems, workforce development, and technological advancement. Even though STEM fields are vital for innovation, economic expansion, and maintaining global competitiveness, many students are becoming disinterested in these subjects, especially in higher education. Understanding the underlying factors that contribute to this decline is essential to addressing the issue and fostering a renewed enthusiasm for STEM education. Many students perceive STEM subjects as overly challenging and intimidating due to their abstract nature and complex content. This perception can discourage students from engaging with these subjects, particularly if they lack adequate foundational understanding. According to Sithole et al. (2017), the institutional factors that contributed to student persistence, motivation, self-efficacy, and success in STEM are student course load, academic advising, and pedagogy. Ivanka (2022) denoted that science camp can indirectly prepare the students via a non-traditional approach to spark their interest in learning STEM.

Addressing the decline in students' interest in STEM education requires a multi-faceted approach. Efforts should focus on revamping teaching methodologies to make STEM subjects engaging and relevant, increasing diversity and representation in STEM fields, providing exposure to diverse STEM careers, and creating accessible avenues for hands-on learning. Additionally, promoting positive role models, integrating real-world applications, and fostering collaborative and interactive learning environments can all contribute to reigniting students' passion for STEM and ensuring a skilled and diverse workforce for the future. Understanding these approaches is one of the alternative methods to consider short-term science camps as informal science education (Foster & Shield-Rolle, 2011).

A lot of studies have been conducted to gauge the effectiveness of science camps in STEM. Foster and Shield-Rolle's (2011) research suggests a good outcome by indicating a favorable influence on students' evaluations of the overall learning environment. Attainments in various fields, inclusive of reading proficiency (Schacter& Jo, 2005), laboratory skills development (Knox et al., 2003), or scientific knowledge and scientific process skills (Aydede Yalcin, 2016). The ownership of the science camp lies with them, contributing to the amplification of intrinsic motivation towards STEM learning. The presence of a science camp serves as a significant motivational factor for students to choose STEM-related education, influencing their future career decisions. Thus, this study aims at upper secondary school students as they are approaching their career decisions.

In this study, the camp is named the Young Scientist Camp (YSC), and this study focuses on the 4th edition of the camp, YSC 4.0 2022. YSC is an annual event hosted by the Centre for Foundation Studies, Universiti Teknologi PETRONAS (UTP). As the pioneer in technology education and a center for creativity and innovation, UTP holds the responsibility of promoting and instilling enthusiasm for science, technology, engineering, and mathematics (STEM) among secondary school students in Malaysia. YSC primarily serves as an eye-opener to students in understanding the significance of STEM, cultivating a culture of innovation, and boosting higher passion in science, technology, engineering, and mathematics among the young generation in educational institutions. Moreover, it also provides students with valuable experience that exposes them to exploring their own creativity and boosts confidence, communication skills, and teamwork. Through this superior learning exposure, it is hoped that YSC will inculcate and enhance students' interest in STEM and eventually choose a career path in STEM that will later contribute to the economic and social advancement of the country.

■2.0 OBJECTIVES

The aim was to find out the students' motivation to compete in a science camp and to gauge their ideas about their professional career. Our research centered around exploring the potential and constraints of science education conducted via science camps, which are considered as informal learning approaches.

1. What internal motivation does the science camp impart in students to learn STEM subjects?
2. Which STEM-related modules are the most enjoyable to the students?
3. What impact does science camp have on students' career decisions?

■3.0 METHODOLOGY

3.1 Participants

Two different research methodological approaches were used during this study. A quantitative method was used through the analysis of pre- and post-survey responses directly after the completion of the camp and after a few months of camp completion. This is to assess their attitudes towards continuing their interest in STEM-related studies. A qualitative perspective is also included in this study to examine the perception of students towards hands-on activities, as it is also one of the contributing factors to the students' motivation. According to Kitzinger (1995), focus groups were used to consider the perspectives of the students who had participated in this camp and to measure their attainment towards the unique modules designed in this camp.

3.2 Procedure and Data Collection

This camp was conducted after the trial examination, prior to the real final examination of the students. The data was collected electronically three times. The first one was collected before the camp, and the second one at the end of the 3-day and 2-night camp. The third is after 10 months of completion of the camp to get an idea of the choice of career that the students opt for.
Each of the students took the survey on their own. We studied the excitement, types of activities, key takeaways, and individual student progress for further data analysis purposes.

3.3 Activities at the Science Camp

The winners were identified by utilizing the cumulative marks, adhering to the criteria outlined in the modules listed in Figure 1. The students are competing against each other in the assigned group for the list of awards, classified either individually or in groups. This procedure is essentially intended to equitably evaluate and honor students' accomplishments and contributions through a comprehensive assessment of their performance, in accordance with the standards outlined in the modules. In addition to encouraging success in the classroom and other pertinent contexts, it fosters healthy competition on both an individual and group basis.

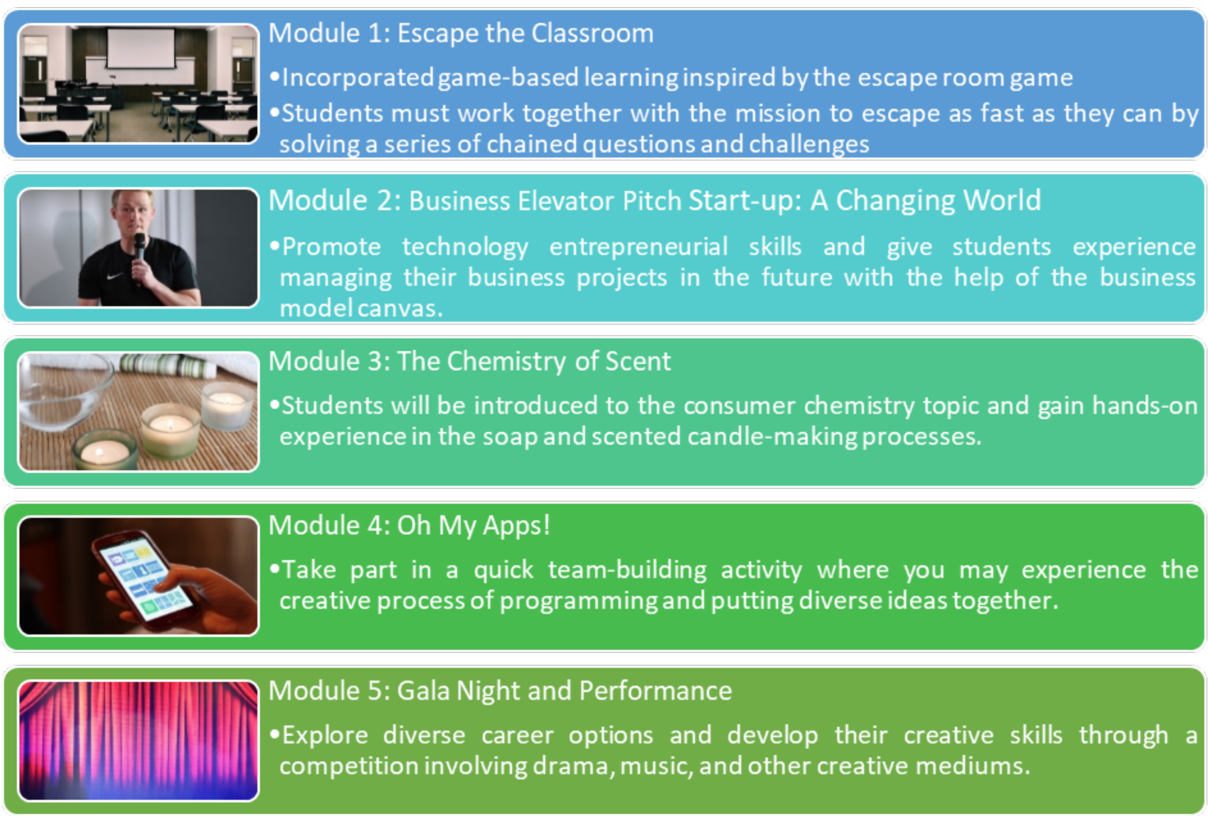

Figure 1 List of modules offered in the camp

The evaluation criteria for each module were summarized in Table 1. In order to ensure fairness, objectivity, transparency, and participant motivation, evaluation criteria are essential in this camp. They simplify the evaluation process, guarantee accountability, enable feedback and progress, give consistency, and concentrate on pertinent abilities. Personalization and data-driven improvement raise the capability and significance of the competition. Figure 2 and Figure 3 shared the snapshots taken during the camp.

Table 1 Evaluation criteria for each module

Module	Category	Criteria of Evaluation
1	Science & mathematics	Time; Solution
2	Business	Creativity; Innovation; Novelty
3	Chemistry (Experiment)	Report (35%); Product (45%); Quiz (20%)
4	Computing	Creativity; Code Sequence and Syntax; Storytelling / game
5	Career planning	Creativity; Values

Figure 2 Event Snapshots

Figure 3 Products developed by the student from Module 3

■4.0 RESULTS AND DISCUSSION

The results are shown in the following two figures to get an initial idea of the students' initial perception. Figure 4 shows that 95% agree that it is difficult for them to understand STEM related content covered in their syllabus and this data was taken into consideration as the preliminary input from the students. This implies that students encounter significant challenges in learning STEM subjects and thus the implementation of creative and engaging modules was beneficial to improve their perception on this. Roberts (2018) study the effects of an informal STEM summer program on students' in-school performance and perceptions towards mathematics and science classes which is regarded as the umbrella in this study.

The combination of practical relevance, problem-solving opportunities, and the potential for making a meaningful impact attracts students to STEM disciplines, despite their complexity. In Figure 5, many of the students agree that the modules prepared and covered in the science camp can directly help boost their interest in learning STEM. One of the reasons might be due to the innovative experiential learning approach introduced to the students to help them to better appreciate STEM. This assertion was supported by consistent findings from previous researchers that correlate the science camp with an active learning environment (Aydede-Yalcin, 2016), problem-based learning approaches (Thomson, 2013), students' acceptability towards STEM career paths (Mohr-Schroeder, 2014), and problem-solving of real-world issues (Capraro, 2013).

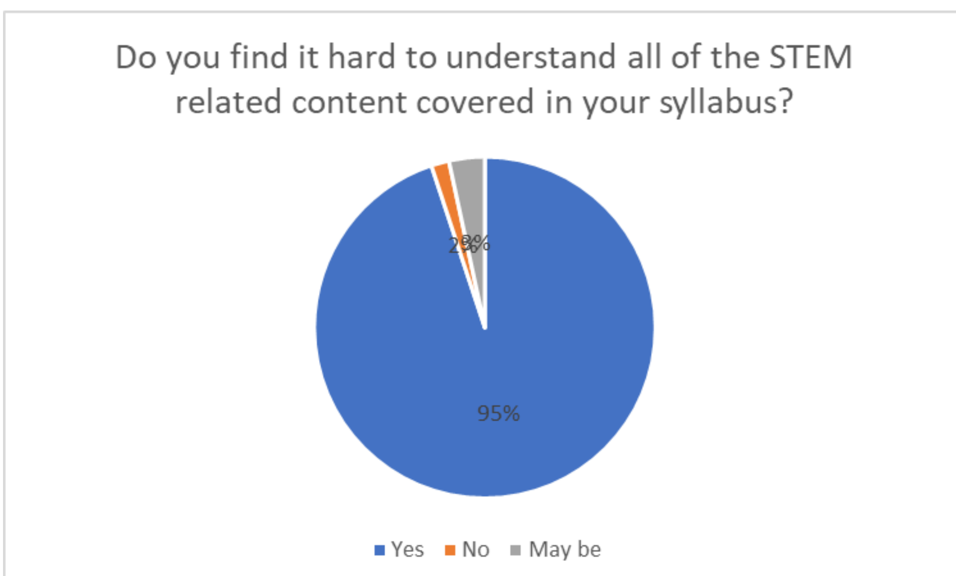

Figure 4 Initial perception on STEM related content covered in the syllabus

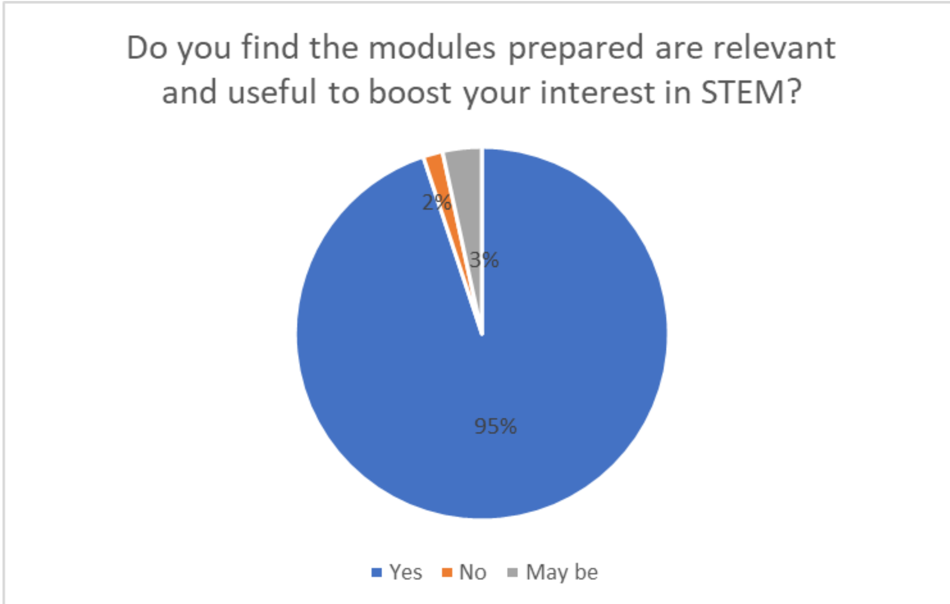

Figure 5 Initial perception of the modules covered in the Science Camp to boost interest in STEM.

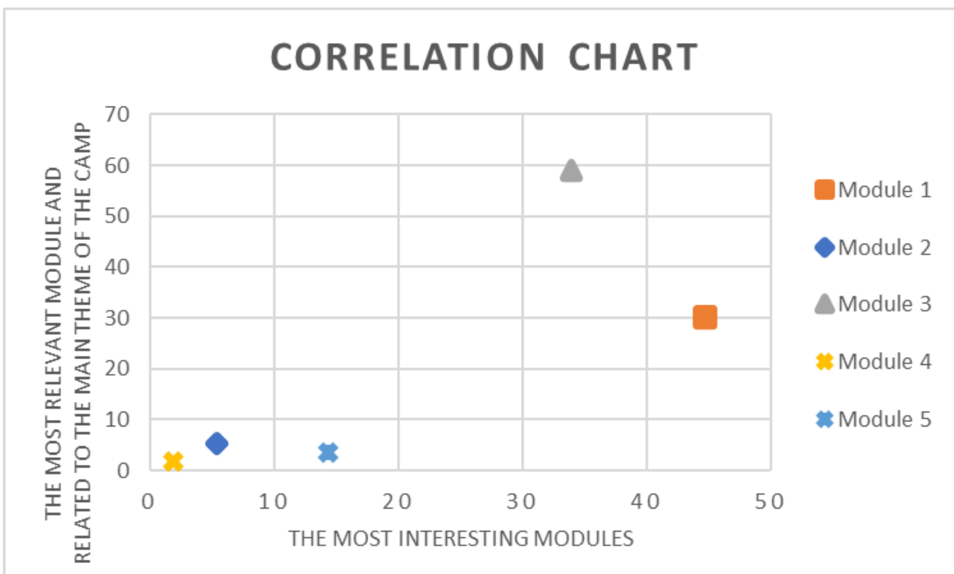

Figure 6 Correlation chart between the modules and the relevancy of the modules.

To determine the validity and significance of the science camp against the modules prepared, as summarized in Figure 6, it was found that Modules 1 and 3 have the most significant impact on the students. In Module 3, students have hands-on and engaging experience in the actual process of making candles and soap, which provides firsthand knowledge of the materials, techniques, and steps involved. Most students will learn better and will appreciate and grasp the concepts more effectively when they engage in hands-on experiences, as these interactive activities foster deeper understanding and active learning activities. According to Nuora (2018), natural learning in an informal environment can indirectly benefit students.

According to research by Zhang (2022), secondary students in Hong Kong strongly preferred technology to other STEM courses. However, this study suggests otherwise, where the hands-on module and direct experimentation as in modules 1 and 3 received better acknowledgement and acceptance.

Although science was appealing to both sexes, there was a sizable gender difference in the interests of STEM careers, with men being more interested than women. It is necessary to improve STEM education, increase the attractiveness of STEM occupations, and promote female involvement in STEM-related fields. Understanding why male and female students differ in their STEM interests enables tailored strategies to bridge the gender gap and meet future workforce needs while ensuring equal opportunities for all. However, for this study, the difference is not being explored.

Chained questions often require students to analyze information, synthesize ideas, and think critically (Johnson, 1992). This process stimulates their intellectual curiosity and helps them develop problem-solving skills and work collaboratively as a team as in the content embedded in Module 1. It can be concluded that the students appreciate activities that offer and spark their interest in STEM through engaging activities where they can work collaboratively.

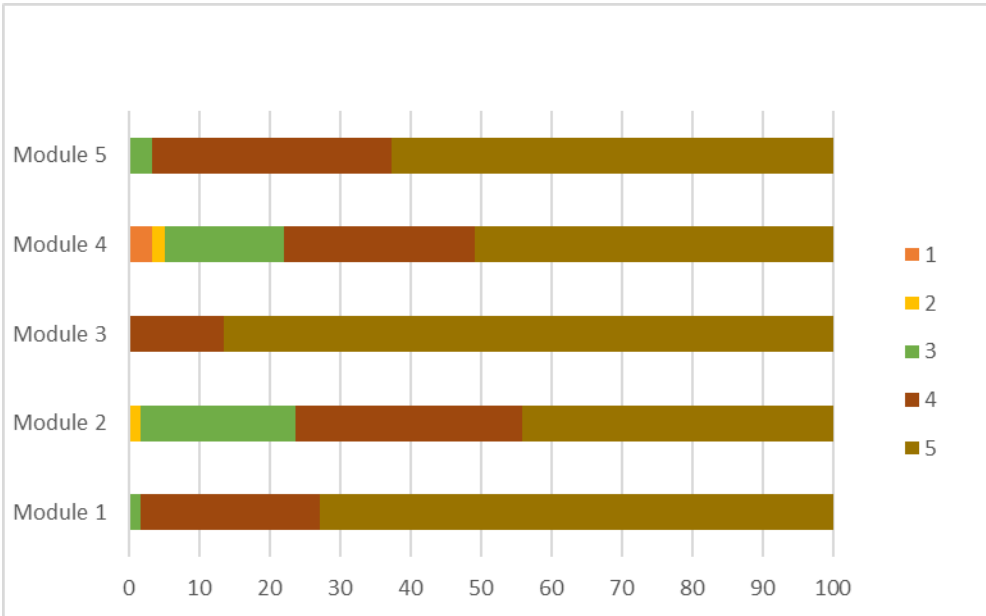

Figure 7 Rating on the experience gained in each module.

Figure 7 shows likert scale analysis, with rating 1 being as unsatisfied and rating 5 as highly satisfied. It was found that the students are giving positive feedback and enjoying all the modules prepared, though the nature of the modules is unique from one to another. The finding is also supported by the work cloud, which summarizes the overall experience and satisfaction of the students (Figure 8). Qualitative and quantitative data obtained from this study supported the affective domains of the motivational aspects instilled in the students at the end of the camp. According to a study conducted by Gan in 2022, learning motivation indirectly influences feedback demonstrated by or to the students. This is believed to be an important tool to gauge the overall learning experience rendered to the students. In terms of the attainment towards competition-based learning approaches adopted in this study, a selected group of students competed healthily to win the awards offered in this science camp, namely overall award winners, individual award winners, and category-based winners. As mentioned by Norazlan (2021), a reward system may become an effective approach in improving students' motivation, success, and attitude indirectly. Students who struggle in traditional classroom settings could experience success in out-of-school settings, leading to continuous success in STEM-related careers (Lauer, 2006).

Figure 8 Summary of the overall experience gained from the Science Camp.

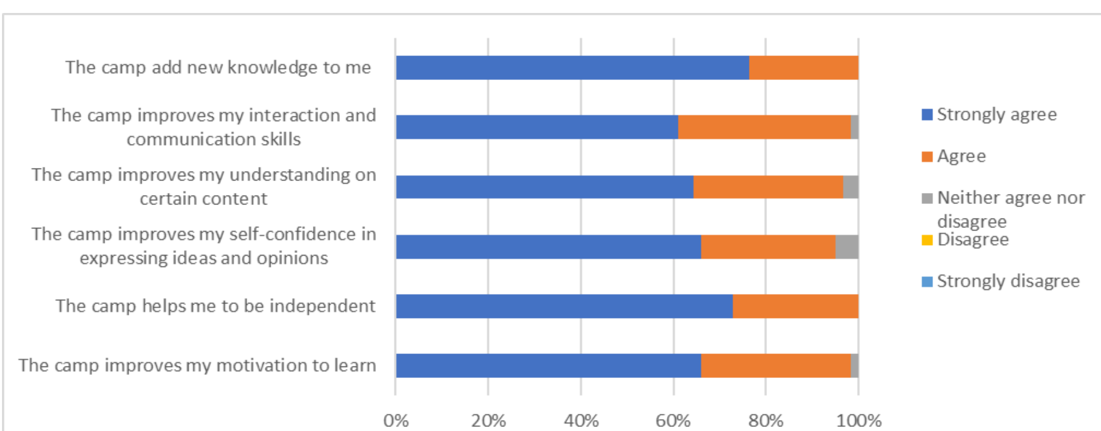

Figure 9 Improvement of soft skills and motivation.

The result shown in Figure 9 proves that the Science Camp has significantly improved their soft skills and motivation to learn STEM. It was found that most of the participants agreed that the camp had provided them with improvements in soft skills and motivation. None of the participants have responded otherwise. Since the attitudes and objectives that propel an individual to action shape their motivation, motivational elements can act in concert or apart to influence motivation (Eccles, 1998; Ryan, 2000). Another study by Mohd. Zahidi (2021) also suggests that well-designed science camps can be valuable for motivating young children to explore and engage with science, offering insights for future camp design and methodology. As reported in Figure 10, after the completion of the science camp, the majority of the students agreed that they were interested in pursuing careers in the fields of engineering and science, which gives a clear idea of the impact instilled in them by the camp itself. It is then proven from the input provided that the students still chose STEM-related fields as their current program (Figure 11).

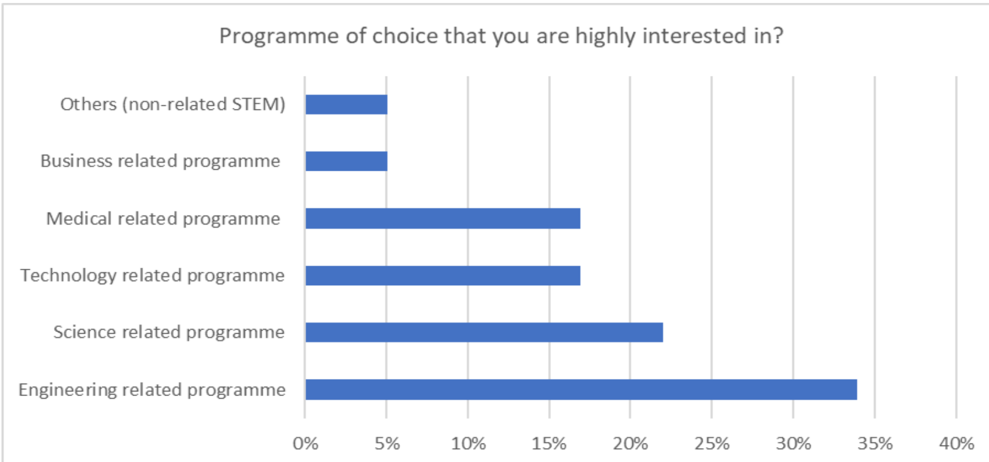

Figure 10 Preferred programme of choice after the completion of the Science Camp.

The experience gained in a science camp and the opportunity provided reflects career decisions. The students have been exposed to the various career opportunities in Module 5. Hence, from the data obtained right after the Science Camp ended, it is proven that nine out of ten students are influenced to pursue STEM related career. According to a study by Abe (2020), there are three key factors which are interpersonal (family, teachers, peers), intrapersonal (personal traits, experiences) and career outcome expectations that will influence students' career choices. Students should also consider external influences, self-awareness and long-term prospects when making career shifts.

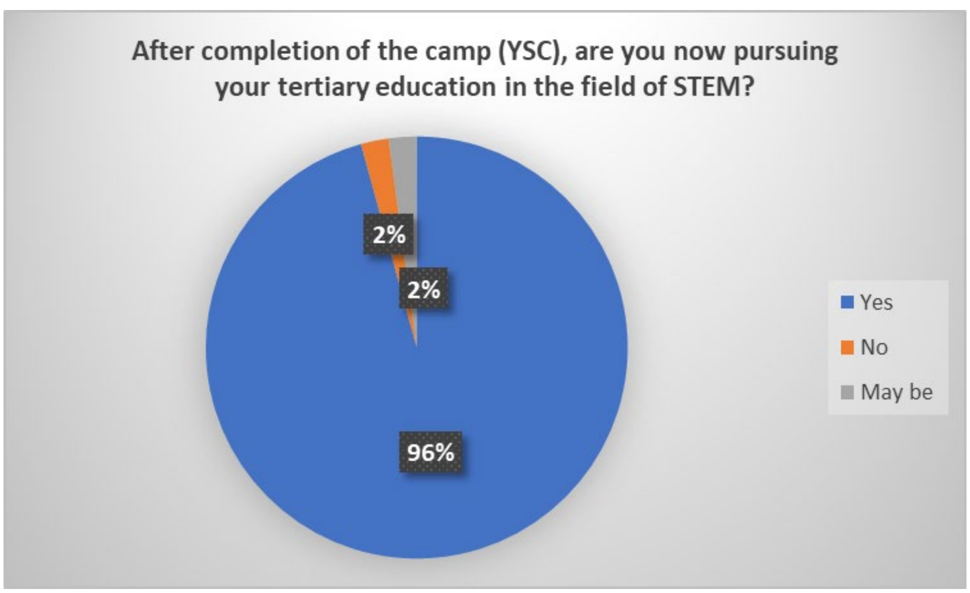

Figure 11 Evidence of career of choice.

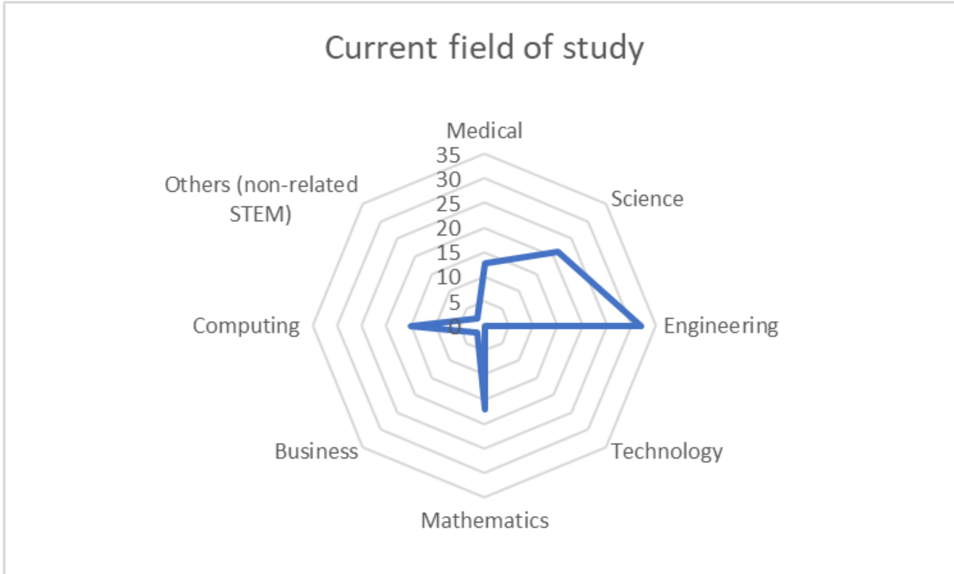

Figure 12 Current field of study.

After 10 months, another survey has been launched to collect data on the number of students who are currently pursuing their tertiary education in the field of STEM. It is exceptionally coherent that more than 95% of the students are now in the field of STEM, whereas most of the students are now in the field of engineering (Figure 12).

Even though the benefits of the science camp are evident, there are limitations to be considered for future research. The first limitation is the limited incorporation of active learning and engaging activities for selected modules that are unable to spark the interest of the students. Another limitation is the self-report, which may contribute to monomethod bias. Various motivational factors, including the gender factor and the family income factor, needed to be incorporated into the study to further evaluate the effectiveness of the students' motivation and decision to pursue a career in a STEM-related field. This is important to better understand the combination of motivational beliefs and motivational needs towards engaging and interactive experiential learning in Science Camp.

The study was limited to the small group of students who participated in the camp, who were mostly science students from boarding schools. Future studies should incorporate a larger sample size from various types of learners across Malaysia to better generalize the results. In this study as well, we did not explore the role of individual characteristics when assigning the students to groups. Future studies should consider the background of individual students, as it is one of the contributing factors that promotes better group focus and drive, as the modules were designed to be competition-based. Future studies should also consider more statistical analysis to better understand the data gathered. Furthermore, the correlation between students' motivation and their achievements should be explored in detail to further analyze the effectiveness of having a science camp that promotes problem-based learning, experiential learning, and competition-based learning.

■6.0 CONCLUSION

The main contribution of the study sheds new light on understanding various stages of work that lead to successful content development in Science Camp, which can indirectly increase the awareness and interest of students in pursuing their studies in STEM-related programs. Science camps have the potential to contribute to preparing individuals for the challenges of the Fourth Industrial Revolution (IR 4.0) by providing the talent and skill set aligned with Malaysia's Shared Prosperity Vision 2030.

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