

Sternberg Thinking Skills among Upper Secondary Vocational Students in STEM Subjects

Yee Mei Heong^{1*}, Murni Farahin Mahmud², Nur Nadia Md Arsad³, Sukardi⁴,
Wan Nur Ilyana Najihah Wan Rojas⁵

^{1,2,3} Faculty of Technical and Vocational Education,
Universiti Tun Hussein Onn Malaysia (UTHM) Parit Raja, 86400 Batu Pahat, Johor, MALAYSIA

⁴ Faculty of Engineering,
Universitas Negeri Padang, Air Tawar, Padang, 25131 West Sumatra, INDONESIA

⁵ Pamir Development Sdn Bhd, Taman Setia Tropika, 81200, Johor Bahru, MALAYSIA

*Corresponding Author: mhyee@uthm.edu.my
DOI: <https://doi.org/10.30880/jtet.2025.17.04.006>

Article Info

Received: 1st April 2025
Accepted: 18th November 2025
Available online: 30th December 2025

Keywords

Sternberg thinking skills, STEM subjects, Application

Abstract

The development of 21st-century skills is crucial for Vocational Education to meet the demands of Industrial Revolution 4.0. This study addresses the gap arising from underperformance in creative thinking and declining achievement in Upper Secondary Vocational Programme (PVMA) STEM elective subjects. Rooted in Sternberg's Triarchic Theory, this research aims to identify the level of analytical, creative, and practical thinking skills among PVMA STEM students and analyse differences based on gender, STEM subjects, and socioeconomic status (SES). A quantitative research design was employed, utilising a survey instrument adapted from Yee et al. (2022). The sample consisted of 158 PVMA students randomly selected from secondary schools in Batu Pahat, Johor. This study employed descriptive and inferential analyses to examine the research data. A significant difference was found in practical thinking skills based on gender ($p = 0.01$). No significant differences were observed between genders in analytical or creative thinking. Furthermore, there was a significant difference in thinking skills based on STEM subjects (Analytical, $p = 0.01$; Creative, $p = 0.02$; Practical, $p = 0.001$). Conversely, no significant differences were found in analytical, creative, or practical thinking skills based on students' socioeconomic status ($p > 0.05$). In conclusion, the findings underscore the impact of gender and specific STEM subjects on cognitive skills. Although socioeconomic status did not yield significant differences, the study supports that experiential and contextual learning approaches can help bridge socioeconomic gaps. These results provide valuable insights for educators and policymakers, underscoring the importance of differentiated teaching strategies and fostering the development of equitable thinking skills among TVET students.

1. Introduction

The Fourth Industrial Revolution (IR 4.0) has become a significant catalyst for transforming the global educational landscape. This transformation requires education systems to produce learners who are not only knowledgeable but also equipped with skills relevant to current industrial needs and dynamics. In line with these demands, educational institutions are now placing greater emphasis on the mastery of 21st-century learning skills as a key foundation for developing human capital. This is closely associated with Science, Technology, Engineering, and Mathematics (STEM) education, which is regarded as a vital component in fostering the application of 21st-century learning skills. (Zihan, 2024). Thinking skills implemented in Malaysian education aim to develop students' abilities to analyse, evaluate, and solve problems (Bael, Nachiappan & Pungut, 2021). Sternberg's triarchic thinking skills further refine these abilities through three main components: analytical, creative, and practical thinking (Sternberg, 2022). This continuity demonstrates that the fundamental principles of thinking skills align with Sternberg's dimensions, as both emphasise information processing, idea generation, and the application of knowledge in real-life situations.

Analytical thinking involves the ability to critically evaluate ideas, plan, implement, and assess information systematically and thoroughly (Sternberg, 2021; Núñez Lira et al., 2019). It also includes organising and testing hypotheses, considering multiple perspectives, and drawing evidence-based conclusions. Creative thinking, on the other hand, refers to the ability to generate novel and innovative ideas to overcome challenges and solve problems (Tok, 2022). Individuals with strong creative thinking skills demonstrate flexibility, imagination, and a willingness to explore diverse approaches to problem-solving. This skill also involves forming new connections between concepts, integrating knowledge from various domains, and taking calculated risks to develop unique and innovative solutions. Practical thinking, as described by Sternberg (2019), relates to applying knowledge effectively in real-world contexts relevant to an individual's life. A key aspect of practical thinking is the acquisition and use of tacit knowledge, where individuals must navigate situations that are not explicitly taught or directly informed, often requiring a combination of analytical and creative reasoning (Azid & Md-Ali, 2020). Taken together, Sternberg's triarchic model provides a comprehensive framework that links general thinking skills with specific cognitive strategies, offering a clear structure for understanding and developing students' higher-order thinking abilities in educational settings.

In the context of PVMA students, Sternberg's three components are highly relevant to their learning in STEM subjects. Analytical thinking enables PVMA students to critically evaluate information, organise data, and draw evidence-based conclusions when conducting experiments or performing technical tasks. Creative thinking allows them to generate innovative solutions, adapt processes, and explore multiple approaches to overcome practical challenges in workshops or industry settings. Practical thinking equips students with the ability to apply knowledge effectively in authentic vocational environments, navigate tasks that are not explicitly taught, and make informed decisions in dynamic situations. Together, these components provide an integrated framework that enhances PVMA students' higher-order thinking skills, bridging theoretical knowledge with practical application, and preparing them for both academic and professional success.

STEM education encompasses both process skills and technical skills. STEM subjects focus on elective areas, including Pure Science and Additional Mathematics, Applied Science and Technology, as well as the Upper Secondary Vocational Programme (PVMA). Through these learning programmes, students can apply scientific concepts, develop practical skills, and gain industrial experience relevant to the STEM field (Ravi & Mahmud, 2021). Furthermore, the integration of STEM education plays a vital role in strengthening critical thinking skills and enhancing students' problem-solving abilities (Davidi, Sennen, & Supardi, 2021). In addition, STEM education promotes interdisciplinary learning that connects theoretical knowledge with real-world applications, thereby fostering innovation and creativity among students (Ahmad & Sajid, 2024).

Therefore, mastery in STEM subjects enables students to acquire essential 21st-century learning skills, which in turn prepare them to face real-world challenges, particularly in future employment sectors. As the world continues to advance alongside technological progress, industries and job markets are increasingly demanding a workforce equipped with diverse and competent skill sets (Rohida, 2018). The development of a skilled workforce plays a crucial role in driving national economic growth, transforming a middle-income economy into a high-income nation (Ali, 2023). Hence, students need to develop a broad range of skills from an early stage of education to enhance their employability (Saleh & Rosli, 2019). This effort also helps mitigate risks associated with various socioeconomic challenges, such as poverty and unemployment (Chamadia & Shahid, 2018). Upon closer examination, employability skills, including thinking skills, serve as a foundational element for knowledge acquisition and the development of other competencies (Saidin & Bukhari, 2023). Thinking skills have long been introduced by the Malaysian Ministry of Education (MOE) and integrated into the teaching and learning process.

In Malaysia, T&L sessions that emphasise thinking skills have been implemented since the early 1990s (Hashim, Mat, Rashid, Zubairi, & Shahrhan, 2022). However, based on the results of the 2022 Programme for International Student Assessment (PISA), Malaysia was found to be among the countries with low performance in creative thinking, recording a mean score of 25 compared to other Asian countries such as Singapore (mean score

41) and Korea (mean score 38) (Hashim et al., 2022). PISA serves as an international benchmark for measuring and comparing countries and economies' performance in creative problem-solving and thinking (Hashim et al., 2018). According to the PISA 2022 report, Malaysian students scored significantly below expectations in innovative thinking. This underperformance has been attributed to the lack of integration of thinking skills during the teaching and facilitation process (Bael, Nachiappan, & Pungut, 2021).

Additionally, the 2020 Sijil Pelajaran Malaysia (SPM) examination results showed that 39 out of the 83 subjects offered experienced a decline in performance (Lembaga Peperiksaan, 2021). Among the subjects that showed a decrease in performance were the STEM elective subjects under the PVMA. This decline may be attributed to the limited competence of STEM educators in implementing creative teaching approaches during classroom teaching and learning sessions. This issue arises partly because some teachers lack a clear understanding of the concept of 21st-century teaching and learning (Yahaya, Hanafiah, Zakaria, Osman, & Bahrin, 2019). Consequently, the lesson plans prepared by these teachers often do not align with the expectations of 21st-century education (Nagaretnam & Mahmud, 2022). Furthermore, according to Ravendran and Daud (2019), many teachers were reluctant to integrate technology into their teaching and learning practices, as they perceived that preparing digital tools and materials was too time-consuming.

This declining performance may be attributed to STEM education teachers who lack competence in practising creative teaching during classroom teaching and learning (T&L) sessions. This issue arises because some teachers have an unclear understanding of the concept of 21st-century teaching (Yahaya et al., 2019). As a result, the lesson plans they develop do not fully meet the demands of 21st-century learning (Nagaretnam & Mahmud, 2022). According to Ravendran and Daud (2019), teachers also exhibit limited initiative in integrating technology into their lessons, as they perceive that preparing digital materials and resources is time-consuming.

Overwhelming workload has led teachers to face time constraints in implementing 21st-century teaching practices (Nagaretnam & Mahmud, 2022). Teacher workload has a significant impact on classroom instruction and affects students' learning outcomes (Muttalip, Amir, & Amat, 2021). Consequently, many teachers resort to traditional, one-way teaching methods and provide fewer activities or exercises that stimulate students' thinking skills (Setambah et al., 2019). As a result, students' critical and creative thinking abilities have become stagnant and underdeveloped (Agir, Effendi, & Matore, 2022). In the context of STEM subjects, students' thinking skills, particularly in problem-solving, remain at a moderate level (Rahayu, Syah & Najib, 2021).

The continuous use of traditional teaching methods has impeded the development of critical and creative thinking among students (Agir, Effendi, & Matore, 2022). In the context of STEM subjects, students' thinking skills—particularly those involving problem-solving—remain at a moderate level (Rahayu, Syah & Najib, 2021). This is partly due to teachers' limited mastery of thinking skills, which has not yet reached an optimal level to effectively enhance students' cognitive abilities (Davidi, Sennen & Supardi, 2021). Consequently, students struggle to apply their knowledge using appropriate thinking skills to solve problems in the subjects they study (Zakaria & Iksan, 2020). This situation prevents students from fully demonstrating their abilities and potential, leading to reduced engagement and a lack of interest in learning. This aligns with Sukri and Nachiappan (2021), who assert that students who are not interested in the teaching and learning process are more likely to skip school.

This situation contributes to students' underwhelming academic performance. Consistent with the findings of Hasrin and Maat (2022), declining achievement is influenced not only by students' interest but is also frequently associated with their level of motivation (Hammoudi, 2020). Furthermore, STEM subjects are often perceived as "killer subjects" due to the difficulty in understanding complex concepts and the extended time required to work through related problems. As a result, students tend to become easily discouraged when learning STEM subjects. This leads to reduced student confidence and heightened anxiety toward STEM subjects. Consequently, students develop negative perceptions of STEM, viewing these subjects as abstract, complex, and uninteresting (Musa et al., 2022).

However, gender has also been shown to influence students' Sternberg thinking skills. Although gender differences are frequently discussed in educational research, there remains a lack of in-depth studies examining how gender specifically affects thinking skills and contributes to students' reluctance to pursue STEM subjects. Gender differences also shape students' learning approaches. This finding is supported by Arbaa, Jamil, and Razak (2010), who discovered that female students tend to adopt different learning approaches compared to their male counterparts. Male students, on the other hand, are more likely to employ learning strategies considered more effective for STEM-related learning (Aris, Samsudin, & Ishak, 2021).

In addition, the subjects students choose also influence their thinking skills. As reported by Zulazmi and Surat (2021), different subjects require different types of thinking skills. Students enrolled in STEM subjects are more inclined to use higher-order thinking skills (R. Ahmad et al., 2021). Thinking skills are closely related to students' learning approaches (Soh et al., 2020); therefore, both thinking skills and learning approaches are shaped by the subject areas students undertake. Basari and Siew (2022) also emphasise that students' learning approaches vary across subjects because each discipline requires specific thinking skills and corresponding learning strategies.

Furthermore, socioeconomic status (SES) also affects an individual's ability to develop thinking skills and engage in practical learning approaches. Students from lower SES backgrounds are more vulnerable to falling

behind in their studies. This finding is consistent with those of Subra et al. (2019), who reported that household income is associated with student dropout rates in schools. Therefore, this study will be conducted to identify the patterns and tendencies of students' Sternberg thinking skills in STEM subjects based on their demographic profiles.

This study aims to:

- Identify the level of students' Sternberg thinking skills in STEM subjects based on demographic factors.
- Analyse the differences in thinking skills based on gender.
- Analyse the differences in thinking skills based on STEM subjects.
- Analyse the differences in thinking skills based on socioeconomic status.

2. Methodology

This study employed a survey research design using a quantitative approach. The population consisted of 166 first-year students enrolled in PVMA subjects at secondary schools in Batu Pahat, Johor. The selection of these schools was based on the observed decline in students' achievement in PVMA-related subjects. The PVMA subjects involved included Cooling and Air Conditioning Equipment Services, Furniture Manufacturing, Food Crops, Landscape and Nursery, and Food Preparation. The sample size distribution for the study is based on the population, as outlined in Table 1. Samples from each school were selected using a random sampling technique guided by the Krejcie and Morgan (1970) sample size determination table, resulting in a total sample of 158 students.

Table 1 Population and sample size of the study

Secondary schools	Population	Samples
SMK Tun Ismail	19	18
SMK Datuk Menteri	22	21
SMK Seri Medan	18	17
SMK Permata Jaya	25	24
SMK Senggarang	22	21
SMK Penghulu Saat	21	20
SMK Tunku Putra	19	18
SMK Dato Onn	20	19
Total	166	158

A questionnaire was used as the research instrument for this study. The instrument consisted of two sections: Section A and Section B. Section A gathered respondents' demographic information, including gender, family income level, and the type of elective STEM subjects they were enrolled in. Section B comprised 29 items adapted from Yee et al. (2022), which included 10 analytic items, 10 practical items, and nine creative items. In Section B, the questionnaire items must be answered using a Likert scale ranging from strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4), to strongly agree (5). The respondents in this study voluntarily participated by completing the questionnaire, and their data were used with consent for research and publication purposes.

The content validity of the questionnaire was evaluated by three lecturers from the Faculty of Technical and Vocational Education (FPTV), each recognised for their expertise in STEM education and critical thinking. A pilot study was subsequently conducted by administering the questionnaire to a randomly selected group of 30 students enrolled in PVMA subjects. To ensure the reliability of the instrument, Cronbach's alpha coefficients were computed to assess the internal consistency of the measured variables. The Cronbach's Alpha value is 0.86.

All collected data were analysed using SPSS Version 29. Descriptive statistical methods were employed to determine the frequencies and percentages representing the distribution of thinking skill tendencies according to demographic factors, in support of research objective one. Additionally, inferential statistical methods were used to analyse the differences in thinking skills according to gender, STEM subjects, and socioeconomic status for the research objectives two, three, and four. The normality test conducted using the Shapiro-Wilk test indicated that the data for analytical thinking ($p = 0.00$), creative thinking ($p = 0.00$), and practical thinking ($p = 0.003$) were not normally distributed. Hence, a non-parametric test was required because the data distribution was not normal.

3. Results and Discussion

3.1 Level of Students' Sternberg Thinking Skills in STEM Subjects Based on Demographics

The findings in Table 2 show that 49.4% of male students and 15.8% of female students demonstrated a high level of creative thinking skills. Meanwhile, 45.6% of male students showed limited mastery of analytical thinking skills, and 13.3% of female students exhibited weaker proficiency in practical thinking skills. Additionally, 47.5% of male students and 13.3% of female students demonstrated a high level of practical thinking skills. Although students demonstrated high scores across all three domains, there may be an imbalance between analytical, creative, and practical aspects that hinders the holistic application of thinking skills in real-world situations. The reported high level of thinking skills may reflect conceptual understanding rather than actual application. This finding aligns with Setambah et al. (2019), who noted that students are often less exposed to cognitively challenging activities due to the continued reliance on traditional teaching practices.

In terms of gender, most of both male and female students demonstrated a high level of creative thinking skills. This is because both groups actively engage in completing assignments given by their teachers. Collaborative group work in the classroom also helps to stimulate creative and innovative ideas among students (Raflee & Halim, 2021). Such an approach not only facilitates more effective task completion but also has a positive impact on the development of students' thinking skills. Overall, the finding of a high level of thinking skills should be interpreted with caution. Although these results indicate the positive potential of PVMA students in analytical, creative, and practical thinking, they do not negate the existing issues regarding students' weaknesses in applying thinking skills effectively. This suggests that while students possess awareness and potential for critical and creative thinking, they still require more structured pedagogical guidance to use these skills comprehensively within the context of 21st-century learning and workplace demands.

Table 2 Level of students' Sternberg thinking skills based on gender

Thinking skills	Level of thinking	Male		Female	
		<i>f</i>	%	<i>f</i>	%
Analytic	Low	1	0.6	1	0.6
	Middle	42	26.6	19	12
	High	72	45.6	23	14.6
Creative	Low	4	2.5	1	0.6
	Middle	33	20.9	17	10.8
	High	78	49.4	25	15.8
Practical	Low	1	0.6	1	0.6
	Middle	39	24.7	21	13.3
	High	75	47.5	21	13.3

In the context of STEM subjects under the PVMA stream, the majority of students in fields such as Landscape and Nursery, Food Crops, and Cooling and Air Conditioning Equipment Services demonstrated a high level of creative thinking skills. Based on Table 3, students in the fields of Landscape and Nursery subjects also showed a high level of analytical thinking skills. Additionally, in the Food Preparation and Furniture Manufacturing fields, most students demonstrated a high level of practical thinking skills, at 13.3% and 10.8%, respectively. Meanwhile, 10.1% of students in the field of Food Crops and 9.5% of those in the field of Cooling and Air Conditioning Equipment Services exhibited lower mastery of analytical thinking skills at a high level. Furthermore, 12% of students in Food Preparation and 9.5% of those in Furniture Manufacturing demonstrated lower mastery of creative thinking skills at a high level.

The variation in students' thinking skills across STEM subjects is likely influenced by the teaching approaches and the nature of coursework practised within each discipline. According to Chai, Surat, and Rahman (2023), the level of thinking skills can also be shaped by individual learning needs and the objectives set within specific subjects. In subjects such as Food Crops, Food Preparation, and Landscape and Nursery, students are encouraged to modify and diversify their outputs to produce more creative presentations, even when tasks are structured and procedural in nature. Meanwhile, subjects like Cooling and Air Conditioning Equipment Services and Furniture Manufacturing require students to solve real-world technical problems, test ideas through hands-on activities, and apply scientific and engineering principles in authentic contexts. This suggests that each subject fosters thinking skills through different modes depending on its learning goals. Overall, all STEM subjects play a vital role in promoting students' ability to generate innovative solutions, albeit through distinct pedagogical pathways.

Table 3 Level of students' Sternberg thinking skills based on STEM subjects

Thinking skills	Level of thinking	Landscape and Nursery		Food Preparation		Food Crops		Furniture Manufacturing		Cooling and Air Conditioning Equipment Services	
		f	%	f	%	f	%	f	%	f	%
		Analytic	Low	1	0.6	0	0	0	0	1	0.6
Middle	15		9.5	20	12.7	19	12	4	2.5	3	1.9
High	28		17.7	20	12.7	16	10.1	16	10.1	15	9.5
Creative	Low	3	1.9	1	0.6	0	0	1	0.6	0	0
	Middle	13	8.2	20	12.7	12	7.6	5	3.2	0	0
	High	28	17.7	19	12	23	14.6	15	9.5	18	11.4
Practical	Low	2	1.3	0	0	0	0	0	0	0	0
	Middle	19	12	19	12	17	10.8	4	2.5	1	0.6
	High	23	14.6	21	13.3	18	11.4	17	10.8	17	10.8

In terms of students' socioeconomic status, those from households earning below RM2,500 demonstrated a high level of creative thinking skills, accounting for 47.47% of respondents. Students with a household income between RM2,501 and RM3,170 demonstrated a high level of practical thinking skills, accounting for 12.03% of the sample. Furthermore, an interesting observation from Table 4.8 reveals that students with a household income between RM3,171 and RM3,970 exhibited both analytical thinking skills and practical thinking skills at a high level, each accounting for 3.8%. Meanwhile, students from the highest income group (RM3,971–RM4,850) also demonstrated a high level of creative thinking skills (5.1%), followed by an equally high level of practical thinking skills (5.1%).

According to Zulkifeli et al. (2022), students from high-income households are likely to have been exposed to various programs that foster the development of creative and practical thinking skills. Although students from low-income families face financial constraints, they actively utilise creative thinking by using inexpensive and readily available materials from their surroundings (Rahayu, 2023). This approach not only promotes the use of recycled and natural materials but also creates opportunities for innovative learning without incurring high costs. Overall, students across different income categories have the potential to enhance their thinking skills through diverse efforts and experiences.

Table 4 Level of students' Sternberg thinking skills based on socioeconomic status

Thinking skills	Level of thinking	x<RM2500		RM2501<x<R M3170		RM3171<x< RM3970		RM3971<x< RM4850	
		f	%	f	%	f	%	f	%
		Analytic	Low	2	1.3	0	0	0	0
Middle	41		26	12	7.6	5	3.2	3	1.9
High	68		43	15	9.5	6	3.8	6	3.8
Creative	Low	3	1.9	2	1.3	0	0	0	0
	Middle	33	20.9	10	6.3	6	3.8	1	0.6
	High	75	47.5	15	9.5	5	3.2	8	5.1
Practical	Low	1	0.6	1	0.6	0	0	0	0
	Middle	47	29.8	7	4.4	5	3.2	1	0.6
	High	63	39.9	19	12	6	3.8	8	5.1

3.2 Differences in Thinking Skills Based on Gender

Table 5 shows the Mann–Whitney U test results, which revealed a significant difference ($p = .01$) in practical thinking skills, with a small effect size ($r = .22, Z = -2.712$). A small value with a small effect size indicates that the difference is real, but perhaps too small to be worth implementing in practice. Practical thinking within Sternberg's framework refers to the ability to apply knowledge effectively in real-world contexts and solve

authentic problems (Sternberg et. al., 2021). This dimension is particularly relevant to the gender context, where learning emphasises hands-on application, workplace readiness, and the ability to translate theoretical understanding into practical action (Zeng & Liu, 2024). In TVET programmes, students are frequently required to navigate real-life tasks, operate industry-standard equipment, and make context-based decisions, skills that directly reflect the core elements of practical thinking (Kasim, Puad & Abdullah 2024). Therefore, integrating practical thinking into the conceptual framework not only aligns with the experiential nature of TVET education but also strengthens students' capability to respond to workplace challenges, adapt to dynamic industrial demands, and demonstrate competency in authentic problem-solving situations (Xinming, 2023).

The higher performance of male students in practical thinking may be associated with their greater involvement in hands-on and technical activities, such as construction, repair work, or experimental tasks requiring motor skills and applied problem-solving (Zakaria & Daud, 2020). Although female students also play a crucial role in the TVET ecosystem, structural inequalities persist; women in technical fields tend to face more limited employment opportunities, lower wages, and fewer prospects for career advancement compared to their male counterparts (Che Ros et al., 2021). Such disparities may also influence exposure, opportunities, and confidence levels, thereby affecting the development of practical thinking skills.

In contrast, no significant differences were found for analytic thinking ($r = 0.11$, $Z = -1.366$, $p = 0.17$) or creative thinking ($r = 0.13$, $Z = -1.591$, $p = 0.11$), as indicated by the Mann-Whitney U test results across gender. The small effect sizes further confirm that gender has minimal influence on students' analytic and creative thinking performance. These findings suggest that although male students demonstrated higher levels of practical thinking, this advantage does not extend to analytic or creative domains. One possible explanation is that both male and female students are similarly exposed to classroom activities that encourage participation, such as completing teacher-assigned tasks and working collaboratively in groups. Such learning environments may help equalise opportunities for both genders to develop analytic and creative skills by allowing them to generate, discuss, and refine ideas collectively (Haron & Sumari, 2024). Consequently, the absence of gender differences in these domains may reflect the effectiveness of instructional practices that promote equitable engagement and support higher-order thinking among all students.

Table 5 Differences in thinking skills based on gender

Gender	Thinking Skills		
	Analytic	Creative	Practical
Male	N	115	115
	Mean Rank	82.53	83.03
Female	N	43	43
	Mean Rank	71.40	70.07
Mann-Whitney U		2124.00	2067.00
p		0.17	*0.01

*Significant differences at $p < .05$

3.3 Differences in Thinking Skills Based on STEM Subjects

The Kruskal-Wallis H test indicates a significant difference between STEM subjects and thinking skills. The results of the Kruskal-Wallis test suggest that there are substantial differences in thinking skills based on the STEM subjects taken. The effect size was a small effect for analytic thinking skills ($\epsilon^2 = .07$, $H(4) = 14.01$, $p = .01$); creative thinking skills ($\epsilon^2 = .05$, $H(4) = 12.31$, $p = .02$); and practical thinking skills ($\epsilon^2 = .10$, $H(4) = 19.76$, $p = .001$). This shows that although STEM subjects influence students' thinking skills, the practical impact of subject differences is that they do not have a meaningful effect. As shown in Table 6, students enrolled in Cooling and Air Conditioning Equipment Services recorded the highest mean ranks across all types of thinking skills: Analytical (109.19), Creative (107.08), and Practical (115.36). Students in the Furniture Manufacturing program also demonstrated relatively high performance, particularly in practical thinking skills (99.26). In contrast, students in the Food Preparation field obtained the lowest scores in both creative (62.66) and practical thinking skills (68.91).

Technical subjects such as Cooling and Air Conditioning inherently promote practical thinking because they require students to apply knowledge directly within real-world environments (Shanta, 2022). Technical subjects require students to solve real-world technical problems, test ideas through hands-on activities, and apply scientific and engineering principles in authentic contexts (Renaud-Assemat, Li, & Egger, 2023). This hands-on,

application-focused requirement directly aligns with and necessitates the development of practical intelligence. According to Sternberg (2022), practical thinking refers to the ability to apply knowledge effectively in real-world contexts, a process that is inherently embedded in technical and vocational subjects where students frequently troubleshoot equipment, perform maintenance tasks, and make context-dependent decisions.

These findings indicate that the type of STEM subject plays a crucial role in shaping and influencing students' levels of thinking skills. Students enrolled in Cooling and Air Conditioning Equipment Services and Furniture Manufacturing demonstrated higher levels of thinking skills compared to those in other fields. This may be attributed to the hands-on, problem-based learning approach commonly applied in these areas, which actively stimulates students to think analytically, creatively, and practically (Kasim, Puad, & Abdullah, 2024). For example, project-based and design-based learning in technical fields has been shown to significantly enhance creative and critical thinking abilities (Zhan & Niu, 2023). In contrast, Food Crops and Food Preparation often emphasise procedural knowledge, routine tasks, and repetition (Sahak & Kutty, 2024).

While these fields are essential and can involve problem-solving, the opportunities for open-ended inquiry, design, and innovation are generally fewer. However, both field holds significant potential in fostering higher-order thinking skills, particularly in the domains of creative and aesthetic thinking. This field demands a high level of creativity, meticulous attention to detail, and aesthetic visualisation to produce dishes that are both visually appealing and well-balanced (Sahak & Kutty, 2024; Velasco, Michel, Woods & Spence, 2016). Nevertheless, students' mastery of thinking skills in this area may vary depending on the teaching approaches employed. When learning activities focus primarily on routine practices without emphasising innovation and design elements, students' potential to develop creative thinking skills may not be fully realised.

Table 6 Differences in thinking skills based on STEM subjects

STEM Subjects		Thinking Skills		
		Analytic	Creative	Practical
	N	35	35	35
Food Crops	Mean Rank	67.11	79.79	70.03
Landscape and Nursery	N	44	44	44
	Mean Rank	80.10	81.32	72.56
Furniture Manufacturing	N	21	21	21
	Mean Rank	92.81	83.64	99.26
Cooling and Air Conditioning Equipment Services	N	18	18	18
	Mean Rank	109.19	107.08	115.36
Food Preparation	N	40	40	40
	Mean Rank	69.33	62.66	68.91
Kruskal-Wallis H		14.01	12.31	7.36
p		*0.01	*0.02	*0.001

*Significant differences at $p < .05$

3.4 Differences in Thinking Skills Based on Socioeconomic Status

The analysis using the Kruskal-Wallis H test revealed no statistically significant differences ($p > 0.05$) in analytical, creative, or practical thinking skills among students based on their socioeconomic status. The analysis indicated that the effect sizes for analytic thinking skills ($\epsilon^2 = .018$, $H = 6.69$, $p = .15$), creative thinking skills ($\epsilon^2 = .015$, $H = 6.22$, $p = .18$), and practical thinking skills ($\epsilon^2 = .004$, $H = 4.59$, $p = .33$) were all within the small-effect range. These results indicate that there were no statistically significant differences in thinking skills, and the practical impact of any discrepancies between the groups was minimal, with no meaningful effect. This finding suggests that in the context of the PVMA, socioeconomic factors do not significantly differentiate students' measured thinking skills. Vocational Education places strong emphasis on applied learning and task-based instruction, where students learn through hands-on activities and practical tasks. This approach reduces dependence on students' financial resources, as practical equipment and materials are typically provided by the institution (Doran, 2022).

Although students from high-income families generally have greater access to additional educational resources, digital devices, and home support, students from lower socioeconomic backgrounds can still develop crucial skills through alternative means (Saratha & Jayabalan, 2021). Students from lower-income families

actively utilise creative thinking by using inexpensive and readily available materials from their surroundings (Mamat & Abdul Wahab, 2022). These findings indicate that differences in students' backgrounds do not influence an individual's thinking skills, as each person has their own unique ways and potential to develop their cognitive abilities.

The requirement for analytical and practical skills focuses on hands-on activities and contextual learning approaches, emphasising real-world problem-solving and relying less on financial resources (Rahman & Osman, 2021). This experiential learning environment acts as a level playing field. This aligns with the findings of Rahman and Osman (2021), who emphasised that experiential learning is more effective in enhancing higher-order thinking skills than socioeconomic factors alone. Besides, creative thinking skill is also shown to be decoupled from financial means. This is because thinking skills are closely related to an individual's motivation, engagement in learning, technical experience, and personal willingness to improve (Hwang et al., 2022).

Table 7 Differences in thinking skills based on socioeconomic status

Socio-Economic Status		Thinking Skills		
		Analytic	Creative	Practical
Below RM 1000	N	40	40	40
	Mean Rank	80.81	77.96	78.00
RM1001-RM2500	N	71	71	71
	Mean Rank	82.70	84.11	80.59
RM2501-RM3170	N	27	27	27
	Mean Rank	68.59	70.22	73.20
RM3171-RM3970	N	11	11	11
	Mean Rank	60.14	59.59	70.05
RM3971-RM4850	N	9	9	9
	Mean Rank	104.83	102.17	108.00
Kruskal-Wallis H		6.69	6.22	4.59
p		0.15	0.18	0.33

*Significant differences at $p < .05$

4. Conclusion

This study investigated the level and differences in Sternberg's thinking skills among students in the PVMA STEM subjects, utilising Sternberg's conceptual categories of analytical, creative, and practical thinking. Overall, the findings suggest that PVMA STEM students generally demonstrate a high level of potential across all three types of thinking skills.

A statistically significant difference was found only in practical thinking skills ($p = 0.01$), with male students exhibiting higher mean ranks. However, no significant differences were observed between male and female students in analytical thinking ($p = 0.17$) or creative thinking ($p = 0.11$). This suggests that gender disparity in thinking skills is primarily confined to the applied, hands-on domain relevant to technical tasks.

The type of STEM subject played a crucial role in shaping thinking skills, demonstrating significant differences across all three conceptual categories: analytical ($p = 0.01$), creative ($p = 0.02$), and practical ($p = 0.001$). Students enrolled in technical fields, specifically Cooling and Air Conditioning Equipment Services, recorded the highest mean ranks across all three domains. This highlights that subjects requiring hands-on, problem-based learning and real-world application, such as technical and design-based fields, effectively stimulate the holistic development of Sternberg's thinking skills.

Crucially, the statistical analysis revealed no significant differences in analytical ($p = 0.15$), creative ($p = 0.18$), or practical ($p = 0.33$) thinking skills among students based on their socioeconomic status. This outcome demonstrates that the focused nature of vocational training, which emphasises experiential and contextual learning and relies less on external financial resources, may effectively bridge potential socioeconomic gaps in skill development.

In conclusion, while PVMA students possess the potential for high-level thinking, their skill development is significantly influenced by the chosen STEM subject, as well as gender, in the practical domain. The lack of statistical significance related to socioeconomic status suggests that TVET pedagogical approaches offer an equitable environment for fostering cognitive skills. These findings indicate that educators should adopt differentiated instructional strategies and provide structured pedagogical guidance to ensure the comprehensive

application of analytical, creative, and practical skills within the demanding context of 21st-century workforce readiness.

Acknowledgement

The authors would like to express their appreciation to Universiti Tun Hussein Onn Malaysia (UTHM) for their support of this research through the Postgraduate Research (GPPS) Grant No VOT. Q817. Appreciation is extended to the secondary schools in Batu Pahat, Johor, for their cooperation and willingness to grant permission for the researcher to conduct the data collection for this study. Special thanks are also extended to the Principal Investigator for the continuous guidance, encouragement, and invaluable advice throughout the course of this study. Additionally, gratitude is extended to the Faculty of Technical and Vocational Education (FPTV), Universiti Tun Hussein Onn Malaysia (UTHM), for their full cooperation, which significantly contributed to the success of this study.

Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **Conceptualization, overall supervision, critical revision:** Yee Mei Heong; **Literature search, screening of articles, and preparation of figures/tables:** Murni Farahin Mahmud, Yee Mei Heong; **Writing – introduction and background, synthesis of key themes:** Murni Farahin Mahmud, Nur Nadia Binti Md Arsad; **Writing – discussion, future perspectives, and gap analysis:** Murni Farahin Mahmud, Nur Nadia Binti Md Arsad, Wan Nur Ilyana Binti Wan Rojas; **Editing, language polishing, and reference management:** Sukardi, Wan Nur Ilyana Binti Wan Rojas. All authors reviewed and approved the final version of the manuscript.*

References

- Agir, N., Effendi, M., & Matore, E. M. (2022). Amalan kemahiran berfikir aras tinggi (KBAT): Satu tinjauan terhadap pelajar kolej vokasional. *International Conference on Business Studies and Education (ICBE)*, 69-76.
- Ahmad, N., & Sajid, A. (2024). Fostering innovation in STEM education through multidisciplinary collaboration. *Multidisciplinary Journal of Emerging Needs of Curriculum*, 1(1), 39-48.
- Ali, R. (2023). Hubungan kemahiran insaniah dengan kebolehgajian pelajar TVET. *Jurnal Pemikir Pendidikan*, 11, 13-22.
- Bael, B. T., Nachiappan, S., & Pungut, M. (2021). Analisis kesediaan guru dalam pelaksanaan kemahiran berfikir aras tinggi dalam pembelajaran, pengajaran dan pemudahcaraan abad ke 21: Analysis of teachers readiness in implementing higher order thinking skills in learning, teaching and facilitation in 21st century. *Muallim Journal of Social Sciences and Humanities*, 100-119.
- Chai, W. T., Surat, S., & Rahman, S. (2023). Tahap efikasi sendiri dan penguasaan kemahiran berfikir aras tinggi (KBAT) dalam kalangan murid. *Jurnal Dunia Pendidikan*, 4(4), 318-333.
- Che Ros, F. S., Yusri, S. Y. S. M., Yusof, M. R. M., & Nazren, A. R. A. (2021). Kebolehpasaran graduan wanita TVET ILJTM Zon Sabah dalam pemilihan kerjaya. *International Journal of Education and Pedagogy*, 3(3), 44-57.
- Doran, M. (2022). A virtual education intervention to approximate hands-on learning: via task-centred learning praxis. ATHABASCA UNIVERSITY
- Hamdan, N., Yee, M. H., Masran, S. H., Tee, T. K., Sutadji, E., & Fuada, S. (2024). Exploring Marzano higher-order thinking skills: Demographic disparities among technical students. *Journal of Technical Education and Training*, 16(2), 103-118.
- Haron, M. Z., & Sumeri, M. N. (2024). Halatuju pelajar TVET: Pengaruh minat terhadap niat kerjaya pelajar teknologi automotif di Kolej Vokasional Daerah Johor Bahru. *Journal of Research, Innovation, and Strategies for Education (RISE)*, 1(1), 58-71.
- Hashim, R., Mat, M. Z. A., Rashid, A. A., Zubairi, A. M., & Shahrhan, M. F. M. (2022). Pelaksanaan kurikulum pendidikan Islam sekolah menengah bagi menghadapi cabaran pendidikan abad ke-21 dari perspektif guru (Implementation of the secondary school Islamic education curriculum in facing the 21st century education challenges from teachers'). *Jurnal Pendidikan Malaysia*, 47(01), 65-79.

- Hashim, R., Yusoff, W. M. W., Hussien, S., Khalid, M., & Kamalludeen, R. (2018). Aplikasi pedagogi hikmah bagi pengajaran bahasa Malaysia dan bahasa Inggeris abad ke-21. *Jurnal Pendidikan Malaysia*, 43(2), 37–47.
- Hashim, S., Baharudin, N., Rahman, K. A. A., Hussin, I., Asri, K. M., & Zulkifli, N. N. (2022). Observation on teachers' readiness for implementation of higher order thinking skills (HOTS) in technical and vocational education and training (TVET). *Online Journal for TVET Practitioners*, 7(1), 31–40.
- Hwang, G. J., Chang, C. C., & Chien, S. Y. (2022). A motivational model-based virtual reality approach to prompting learners' sense of presence, learning achievements, and higher-order thinking in professional safety training. *British Journal of Educational Technology*, 53(5), 1343-1360.
- Kasim, A. A., Puad, M. H. M., & Abdullah, A. (2024). Exploring problem-solving and critical thinking skills of TVET students: An SME employer perspective. *International Journal Of Academic Research In Economics And Management Sciences*. Vol. 13, No. 4, 331-341
- Muttalip, D. A., Amir, R., & Amat, S. (2021). Hubungan tingkah laku kepimpinan guru besar & beban kerja terhadap prestasi guru. *Jurnal Dunia Pengurusan*, 3(1), 30–40.
- Nagaretnam, M., & Mahmud, M. S. (2022). Kesediaan guru dan keberkesanan pelaksanaan pengajaran matematik abad ke-21 di sekolah rendah: Sebuah tinjauan literatur. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(11)
- Raflee, S. S. M., & Halim, L. (2021). Keberkesanan pemikiran kritis dalam meningkatkan kemahiran dalam penyelesaian masalah KBAT. *Jurnal Pendidikan Sains Dan Matematik Malaysia*, 11(1), 60–76.
- Rahayu, A., Syah, A., & Najib, A. (2021). Higher order thinking skills students in mathematical statistics course base on revised bloom taxonomy in factual and conceptual knowledge dimension. In *Journal of Physics: Conference Series*. IOP Publishing (Vol. 1918, No. 4, p. 042076, pp 1-6).
- Renaud-Assemat, I., Li, D. D., & Egger, D. (2023). Creating authentic learning experiences: A case study on implementing hands-on activities and project-based learning approach in mechanical design courses. In *34th Australasian Association for Engineering Education Conference (AAEE2023)* (pp. 540-548). Gold Coast: Engineers Australia.
- Rohida, L. (2018). Pengaruh era revolusi industri 4.0 terhadap kompetensi sumber daya manusia. *Jurnal Manajemen Dan Bisnis Indonesia*, 6(1), 114–136.
- Sahak, A. A. M., & Kutty, F. M. (2024). Penggunaan aplikasi drawing desk dalam aktiviti plating ke atas minat, kreativiti dan pencapaian bagi pelajar kulinari TVET. In *SEMINAR KEBANGSAAN MAJLIS DEKAN PENDIDIKAN UNIVERSITI AWAM 2024* (p. 145).
- Saidin, N. F., & Bukhari, N. A. M. (2023). Faktor keciciran murid-murid program pemulihan khas (fall behind factors of Malaysian primary school pupils). *Jurnal Pengajian Melayu - JOMAS*, 34(1), 26–48.
- Saleh, N. S., & Rosli, M. S. (2019). Kepentingan pembelajaran abad ke 21 terhadap potensi kebolehpasaran modal insan. *Innovative Teaching and Learning Journal*, 2(2), 71–81.
- Saratha, D. A., & Jayabalan, P. (2021). Hubungan antara penglibatan ibu bapa, status sosioekonomi keluarga dan pencapaian sains murid-murid. *Universiti Teknologi Malaysia*.
- Setambah, M. A. B., Tajudin, N. M., Yaakob, M. F. M., & Saad, M. I. M. (2019). Adventure learning in basics statistics: Impact on students critical thinking. *International Journal of Instruction*, 12(3), 151–166.
- Shanta, S. (2022). Assessment of real-world problem-solving and critical thinking skills in a technology education classroom. In *Applications of Research in Technology Education: Helping Teachers Develop Research-Informed Practice* (pp. 149-163). Singapore: Springer Nature Singapore.
- Siemens, G., Gašević, D., & Dawson, S. Hubungan kemahiran insaniah dengan kebolehgajian pelajar-pelajar politeknik Kota Kinabalu, Sabah. *Jurnal Pengajian UmumL*, 92-99.
- Sternberg, R. J., Glaveanu, V., Karami, S., Kaufman, J. C., Phillipson, S. N., & Preiss, D. D. (2021). Meta-intelligence: Understanding, control, and interactivity between creative, analytical, practical, and wisdom-based approaches in problem solving. *Journal of Intelligence*, 9(2), 19.
- Sternberg, R. J. (2022). The intelligent attitude: What is missing from intelligence tests. *Journal of Intelligence*, 10(4), 116.
- Xinming, Z. (2023). Research on cultivating innovation and practical skills in higher vocational education. *Frontiers in Educational Research*, 6(26), 29-36.
- Yee, M. H. (2024). Sternberg thinking skills levels for vocational college students and analysing demographic disparities. *Online Journal for TVET Practitioners*, 9(1), 122–128.

- Zakaria, S. K., & Daud, M. N. (2020). Kemahiran insaniah pelajar IPTA merentas jantina. *International Journal of Education and Pedagogy*, 2(4), 16–38.
- Zeng, X., Chieng, S. L., & Liu, H. (2024). Bridging theory and practice: Exploring digital transformation in entrepreneurship education through a conceptual curriculum development framework in TVET. *Vocation, Technology & Education*, 1(2), 1-18
- Zhan, Z., & Niu, S. (2023). Subject integration and theme evolution of STEM education in K-12 and higher education research. *Humanities and Social Sciences Communications*, 10(1), 1–13.
- Zihan, Z. (2024). Efektivitas pembelajaran matematika berbasis STEM (Science, Technology, Engineering, and Mathematics). *Jurnal Ilmiah Pendidikan Matematika (JIPM)*, 2(1), 60–63.