

Recognising the Value, Questioning the Choice: STEM Students' Perceptions of TVET and Industry 4.0 in Malaysia

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Abstract

The Fourth Industrial Revolution (Industry 4.0) has created a demand for a skilled workforce with technical, digital, and problem-solving abilities essential for workforce development, and Technical and Vocational Education and Training (TVET) provides such a pathway. Although efforts have been made to improve TVET in Malaysia, misconceptions and negative perceptions still influence students' decisions regarding TVET education. This study examines the perceptions of students in STEM fields concerning the aims of TVET and the factors that may discourage STEM students from pursuing a TVET pathway. The study focuses on students in the STEM A stream, considered a potential talent pool for High-Value Technical and Vocational Education and Training (Hi-TVET) programmes, and is guided by Human Capital Theory and Social Cognitive Career Theory. This quantitative survey involved 720 upper secondary school students aged 16 from four geographical zones in Peninsular Malaysia. Data were collected using a structured questionnaire covering 10 TVET goals and 10 demotivating factors, and analysed using descriptive statistics. The findings revealed a high level of agreement with the objectives of TVET ($M = 4.26$, $SD = 0.69$), indicating that respondents recognised the role of TVET in developing practical skills, employability, and competencies required for Industry 4.0. Although respondents reported a moderate level of agreement with the identified demotivating factors ($M = 3.34$, $SD = 1.04$), the results

do not necessarily indicate strong negative perceptions of TVET. Rather, the relatively high proportion of neutral responses regarding career prospects, educational progression opportunities, programme costs, and Industry 4.0 readiness suggests uncertainty and limited awareness of TVET pathways. These findings imply that information gaps, rather than negative attitudes, may be a more significant factor influencing students' perceptions and future consideration of TVET. The study reveals that, although students in STEM courses generally understand the importance of TVET and its contribution to workforce development for Industry 4.0, social perceptions and lack of awareness remain challenges to making TVET attractive. To encourage greater engagement in TVET, enhanced career guidance, increased exposure to TVET pathways, and raising public awareness are essential.

Keywords: Technical and Vocational Education and Training (TVET), Industry 4.0, STEM Students, Hi-TVET, Career Choice, and Workforce Readiness

Introduction

The advent of the Fourth Industrial Revolution (Industry 4.0) has transformed the nature of work and the competencies required in the global labour market. Rapid advancements in technologies such as artificial intelligence (AI), robotics, automation, the Internet of Things (IoT), and big data analytics have increased demand for a workforce with both technical expertise and digital skills. Consequently, Technical and Vocational Education and Training (TVET) has become a strategic mechanism for developing skilled human capital to support industrial transformation and economic competitiveness. In Malaysia, TVET has been identified as a key pillar of national workforce development, particularly through the promotion of High-Value Technical and Vocational Education and Training (Hi-TVET) programmes aimed at producing graduates who are industry-ready and adaptable to technological change (Yunus et al. 2024; Hanafi et al., 2023).

The growing importance of TVET can be explained through Human Capital Theory, which posits that investment in education and skills development enhances individual productivity, employability, and economic outcomes (Tikly, 2013). In the context of Industry 4.0, TVET plays a crucial role in developing practical, technical, and digital competencies that enable individuals to meet evolving labour market demands. Previous studies have shown that TVET contributes significantly to workforce readiness by equipping learners with industry-relevant skills and fostering employability in technology-driven environments (Yusvana, 2025). Therefore, understanding students' awareness and perceptions of TVET is essential, as these perceptions influence educational aspirations, career choices, and future participation in technical and vocational pathways (Omar et al., 2020; Sibiya & Nyembezi, 2018).

Despite substantial investments and policy initiatives to strengthen TVET, enrolment in technical and vocational programmes remains influenced by social perceptions and individual beliefs. In many countries, including Malaysia, TVET is often seen as a secondary option compared to traditional academic pathways (Amin et al., 2023; Harun et al., 2020). Such perceptions may discourage capable students from considering TVET despite its growing relevance and strong employment prospects. Social influences from parents, teachers, peers, and the wider community also play a significant role in shaping students' educational decisions. From the perspective of Social Cognitive Career Theory (SCCT), career choices are influenced by individuals' beliefs, outcome expectations, and environmental factors (Wang

et al., 2022). Therefore, students' perceptions of TVET goals and the barriers associated with TVET can significantly affect their willingness to pursue technical and vocational education.

Although previous studies have examined awareness and perceptions of TVET among students, limited attention has been given to STEM-stream students, who represent a potential talent pool for Hi-TVET and Engineering Technology programmes. Students enrolled in STEM A pathways possess strong foundations in science and mathematics, making them particularly suitable candidates for future technical and technological careers. Understanding how these students perceive TVET is important for strengthening the talent pipeline required to support Malaysia's Industry 4.0 agenda. Furthermore, examining both positive perceptions of TVET goals and factors that may discourage participation provides a more comprehensive understanding of students' decision-making processes regarding future educational pathways.

This study therefore aims to examine STEM A students' perceptions of TVET goals and the factors that may discourage them from pursuing TVET pathways. Specifically, the study investigates students' awareness of TVET's role in supporting Industry 4.0 and identifies the social, informational, and perceptual barriers that may influence their interest in TVET. The findings are expected to contribute to efforts to enhance awareness, improve the image of TVET, and strengthen the alignment between educational pathways and future workforce requirements.

Methods

The target population for this study comprised upper secondary school students aged 16. Although students in Malaysia typically make decisions about their career pathways or further education after completing secondary school and obtaining the Malaysian Certificate of Education (SPM) at 17 or 18, examining students at 16 is important as it allows researchers to assess their awareness and preparedness before they make these critical educational and career decisions. Drawing on the TVET Goals construct developed by Tun et al. (2021) and the Demotivating Factors construct proposed by Boateng et al. (2024), this study examined students' awareness of TVET goals and the factors influencing their cognitive perceptions and potential intentions towards TVET pathways. Respondents indicated their level of agreement with a series of TVET-related statements using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This paper presents partial findings from a larger study, focusing specifically on respondents' perceptions of TVET goals (10 items) and demotivating factors towards TVET (10 items). A total of 720 respondents participated in the study. The sample was selected using a cluster sampling approach representing four geographical zones in Peninsular Malaysia: the Northern Zone (Kedah, Perak, and Penang), Southern Zone (Malacca and Johor), Eastern Zone (Terengganu and Kelantan), and Central Zone (Selangor, Kuala Lumpur, Putrajaya, and Negeri Sembilan).

All respondents were enrolled in the STEM A package, a science-oriented upper secondary programme comprising core subjects such as Biology, Chemistry, Physics, and Additional Mathematics, in addition to compulsory subjects. The STEM A package aims to strengthen students' competencies in science, technology, engineering, and mathematics (STEM), preparing them for STEM-related higher education and career

opportunities. Furthermore, the STEM A pathway provides a strong foundation for students intending to pursue High-Value Technical and Vocational Education and Training (Hi-TVET) programmes, particularly in Engineering Technology disciplines. The rigorous emphasis on mathematics and science equips students with analytical, problem-solving, and technical skills essential for engineering technology programmes, which integrate theoretical knowledge with practical applications. Consequently, although respondents came from diverse demographic backgrounds, the sample was relatively homogeneous in terms of academic orientation, as all participants were pursuing the STEM A pathway and were therefore well-positioned for future studies and careers in STEM and Hi-TVET fields. Data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 26, employing descriptive statistical techniques to summarise respondents' perceptions.

Results

The results on respondents profile were summarized as follows:

Table 1

Respondent Profile

Respondent Profile	n=720	
	<i>f</i>	%
Gender		
Male	336	46.7
Female	384	53.3
Courses/Stream		
Pure Science	446	61.9
Accounting	49	6.8
STEM/Engineering	104	14.4
Geography	8	1.1
Economy	3	0.4
Others	110	15.3

Table 1 presents the demographic profile of the 720 respondents. Female respondents made up a slightly higher proportion of the sample (53.3%, $f = 384$) than male respondents (46.7%, $f = 336$). The majority of respondents were from the Pure Science stream (61.9%, $f = 446$), followed by the Economy stream (15.3%, $f = 110$) and the Geography stream (14.4%, $f = 104$). Smaller proportions were from STEM/Engineering (6.8%, $f = 49$), Accounting (1.1%, $f = 8$), and other streams (0.4%, $f = 3$). These findings indicate that the sample was predominantly female and largely comprised students from the Pure Science stream.

Table 2
TVET Goals

	Item		1	2	3	4	5	Mean	SD
1	I understand that the Fourth Industrial Revolution (Industry 4.0) will bring significant changes to the way industries operate.	f						4.27	0.67
		%	6	6	38	407	263		
2	I believe that the Fourth Industrial Revolution (Industry 4.0) will become a reality in Malaysia within the next few years.	f						4.23	0.62
		%	1	4	56	429	230		
3	I am aware that new technologies such as robots, smart machines, and artificial intelligence will soon become part of our daily lives.	f						4.35	0.70
		%	4	2	62	322	330		
4	I believe that existing TVET programmes are aligned with the skills required to face the challenges of Industry 4.0.	f						4.02	0.72
		%	6	14	101	438	161		
5	I believe that TVET should place greater emphasis on digital and technological skills to support the demands of Industry 4.0.	f						4.30	0.66
		%	3	6	44	383	284		
6	I believe that the Fourth Industrial Revolution (Industry 4.0) will create more new employment opportunities.	f						4.16	0.89
		%	8	24	115	273	300		
7	I believe that TVET graduates will have an advantage in securing jobs related to Industry 4.0.	f						4.20	0.69
		%	3	5	80	396	236		
8	I know that TVET helps students develop practical skills that can be directly applied in future careers..	f						4.37	0.65
		%	4	3	35	361	316		
9	I understand that TVET is not only about technical work but also involves the use of modern technologies such as robotics and computers.	f						4.36	0.65
		%	3	2	46	354	315		
10	I believe that TVET can be a valuable career pathway for addressing the challenges of the Fourth Industrial Revolution (Industry 4.0).	f						4.29	0.68
		%	2	10	53	390	265		
Overall								4.26	0.69

Table 2 presents respondents' perceptions of TVET and the Fourth Industrial Revolution (Industry 4.0). Overall, the findings indicate a high level of agreement, with a mean score of 4.26 (SD = 0.69). This suggests that respondents generally held positive perceptions of Industry 4.0 and recognised the importance of TVET in preparing individuals for future workforce demands. The results show that respondents were aware of the technological

changes associated with Industry 4.0 and viewed TVET as a relevant pathway for developing skills required in an increasingly digital and technology-driven environment.

Among the items, the highest mean score was recorded for Item 8 (*I know that TVET helps students develop practical skills that can be directly applied in future careers*) ($M = 4.37$, $SD = 0.65$), followed by Item 9 (*I understand that TVET is not only about technical work but also involves the use of modern technologies such as robotics and computers*) ($M = 4.36$, $SD = 0.65$) and Item 3 (*I am aware that new technologies such as robots, smart machines, and artificial intelligence will soon become part of our daily lives*) ($M = 4.35$, $SD = 0.70$). These findings indicate that respondents strongly recognised the practical value of TVET and its connection with modern technologies. Respondents also agreed that TVET should place greater emphasis on digital and technological skills (Item 5, $M = 4.30$, $SD = 0.66$) and believed that TVET could serve as a valuable career pathway for addressing the challenges of Industry 4.0 (Item 10, $M = 4.29$, $SD = 0.68$). Collectively, these results suggest that respondents viewed TVET as an important mechanism for developing future-ready skills and enhancing employability in the era of Industry 4.0.

Despite the generally positive perceptions, two items revealed relatively higher levels of uncertainty. Item 4 (*I believe that existing TVET programmes are aligned with the skills required to face the challenges of Industry 4.0*) recorded the lowest mean score ($M = 4.02$, $SD = 0.72$) and a relatively high proportion of neutral responses (14.0%). Similarly, Item 6 (*I believe that the Fourth Industrial Revolution will create more new employment opportunities*) recorded a mean of 4.16 ($SD = 0.89$) and the highest percentage of neutral responses (16.0%). These findings suggest that although respondents generally agreed with both statements, some remained uncertain about the extent to which current TVET programmes fully meet Industry 4.0 requirements and whether technological advancements will ultimately generate more employment opportunities. Such uncertainty may reflect concerns regarding rapid technological change, automation, and the need for continuous curriculum enhancement to ensure TVET remains aligned with future industry demands. Overall, however, the results indicate that respondents hold favourable perceptions of TVET and acknowledge its significant role in preparing future graduates for the opportunities and challenges associated with Industry 4.0.

Table 3

Demotivating Factors

	Item		1	2	3	4	5	Mean	SD
1	I feel that TVET is often regarded as a second choice compared to the academic stream.	f	17	42	134	327	200	3.90	0.95
		%	2.4	5.8	18.6	45.4	27.8		
2	I am less interested in TVET because society still tends to look down on TVET students.	f	52	93	264	232	79	3.27	1.05
		%	7.2	12.9	36.7	32.2	11.0		
3	My parents are less supportive of me choosing TVET.	f	65	107	234	216	98	3.24	1.13
		%	9.0	14.9	32.5	30.0	13.6		
4	My teachers encourage me more to choose the academic stream rather than TVET.	f	43	66	239	250	122	3.48	1.06
		%	6.0	9.2	33.2	34.7	16.9		

5	I feel that opportunities for further education after TVET are limited.	f	41	93	329	205	52	3.19	0.95
		%	5.7	12.9	45.7	28.5	7.2		
6	I am concerned that jobs in the TVET field may not be stable in the future.	f	36	120	284	205	75	3.23	1.01
		%	5.0	16.7	39.4	28.5	10.4		
7	I am less interested in TVET because I believe that salaries in TVET-related occupations are lower than in other careers.	f	54	144	298	166	58	3.04	1.03
		%	7.5	20.0	41.4	23.1	8.1		
8	I believe that the cost of pursuing TVET is high.	f	48	100	347	173	52	3.11	0.96
		%	6.7	13.9	48.2	24.0	7.2		
9	I am less interested in TVET because I have not received sufficient exposure to TVET-related fields..	f	44	80	209	273	114	3.46	1.08
		%	6.1	11.1	29.0	37.9	15.8		
10	I feel that the TVET field does not suit my interests or abilities.	f	63	79	209	193	176	3.47	1.22
		%	8.8	11.0	29.0	26.8	24.4		
Overall							3.34	1.04	

Table 3 presents respondents' perceptions of factors that may discourage them from pursuing TVET. Overall, the results indicate a moderate level of agreement with the identified demotivating factors, as reflected by the overall mean score of 3.34 (SD = 1.04). This suggests that while respondents acknowledged certain barriers and negative perceptions towards TVET, these factors were not strongly endorsed by most respondents. The findings imply that respondents generally had some reservations about TVET, although the level of concern was considerably lower than their positive perceptions of TVET reported in Table 2.

Among the identified factors, Item 1 (*I feel that TVET is often regarded as a second choice compared to the academic stream*) recorded the highest mean score (M = 3.90, SD = 0.95). More than seventy percent of respondents agreed or strongly agreed with this statement (73.2%), indicating that the perception of TVET as a secondary educational pathway remains prevalent. This was followed by Item 10 (*I feel that the TVET field does not suit my interests or abilities*) (M = 3.47, SD = 1.22), Item 9 (*I am less interested in TVET because I have not received sufficient exposure to TVET-related fields*) (M = 3.46, SD = 1.08), and Item 4 (*My teachers encourage me more to choose the academic stream rather than TVET*) (M = 3.48, SD = 1.06). These findings suggest that social perceptions, limited exposure to TVET pathways, and the continued emphasis on academic education by schools may influence students' interest in pursuing TVET. The results indicate that awareness and guidance-related factors may play a significant role in shaping students' educational preferences.

Despite the moderate level of agreement, several items recorded substantial proportions of neutral responses, indicating uncertainty among respondents. For example, Item 5 (*I feel that opportunities for further education after TVET are limited*) recorded the highest neutral response (45.7%) with a mean of 3.19 (SD = 0.95). Similarly, Item 8 (*I believe that the cost of pursuing TVET is high*) recorded 48.2% neutral responses and a mean of 3.11 (SD = 0.96), while Item 7 (*I believe that salaries in TVET-related occupations are lower than in other careers*) recorded 41.4% neutral responses and the lowest mean score (M = 3.04, SD = 1.03).

These findings suggest that many respondents lacked sufficient knowledge regarding TVET costs, career progression opportunities, and income prospects. Therefore, while respondents recognised certain social and informational barriers to TVET participation, they appeared less certain about structural issues such as financial costs, future earnings, and educational progression pathways. Overall, the findings highlight the need to improve public awareness, career guidance, and the dissemination of accurate information regarding TVET opportunities, career prospects, and progression routes to reduce misconceptions and strengthen students' interest in pursuing TVET programmes.

Discussion

The results of both Tables 2 and 3 provide useful information on respondents' perceptions of TVET in the era of Industry 4.0. Overall, participants expressed very positive attitudes towards the objectives of TVET, particularly in equipping them with practical skills, technical skills, and skills for the future job market. The positive perceptions of respondents regarding the role of TVET in preparing students for Industry 4.0 are consistent with Rokeman et al. (2024), who emphasised that digital competence and technology integration are essential elements of TVET in supporting Industry 4.0 readiness. The findings showed that all respondents belonged to the STEM A stream, implying that STEM students with adequate science and mathematics competencies recognise the relevance of TVET and Hi-TVET pathways to future careers in engineering technology and other high-value technical fields. The finding that respondents strongly agreed TVET develops practical and employability skills aligns with Kholifah et al. (2025), who found that digital competencies acquired through vocational education significantly contribute to workforce readiness and employability in the context of Industry 4.0. The findings, therefore, indicate that TVET is indeed gaining momentum as a means of producing a skilled workforce to meet the needs of Industry 4.0.

Despite these positive perceptions, respondents also identified factors that could deter students from pursuing TVET. The main challenge was the misconception that TVET is still regarded as a second-best option compared to academic education. Previous studies also reported the existence of social stigma and misconceptions surrounding TVET, resulting in lower attractiveness compared to academic pathways (Omar et al., 2023).

Respondents also noted that limited exposure to TVET opportunities and a preference for academic careers among teachers could influence students' study choices. The results indicate that students' preferences for TVET are shaped by both the perceived value and goals of TVET, as well as the nature of their education. The relatively high levels of support for TVET goals, alongside moderate agreement with "demotivating" factors, suggest discrepancies between the benefits recognised in TVET and its social image among students and the wider community.

Additionally, there were relatively high numbers of neutral responses to several items in both tables, such as the alignment of current TVET programmes with Industry 4.0 requirements, future employment prospects, salary expectations, educational progression pathways, and programme costs. This pattern indicates that respondents are not necessarily negative about TVET, but likely lack sufficient information about the actual opportunities offered by TVET and Hi-TVET pathways. Therefore, there is a need to strengthen career guidance, increase students' exposure to TVET programmes, and raise public awareness of TVET career

outcomes. Stakeholders can help build students' confidence in TVET and encourage greater participation in technical and vocational education as a strategic option for future workforce development by dispelling misconceptions and providing clearer information about educational progression, employability, and readiness for Industry 4.0. Magagula & Awodiji (2024) highlighted the need for ongoing curriculum updates, stronger industry collaboration, and increased integration of Industry 4.0 technologies within TVET programmes.

Conclusion

The results indicated that respondents generally have positive attitudes towards TVET and understand its significance in preparing the future workforce for the challenges and opportunities of Industry 4.0. TVET respondents recognised the importance of TVET in developing practical, technical, and technological skills required in modern industries. They also understood that TVET and Hi-TVET pathways can contribute to further studies and career opportunities in engineering technology and other high-value technical fields, such as for STEM A students. Based on these findings, the common objectives of TVET – producing a competent, adaptable, and industry-ready workforce – are well known and valued among TVET students.

However, the study also identifies challenges that may dampen students' enthusiasm for TVET. Negative perceptions of TVET, lack of awareness of TVET opportunities, and the ongoing preference for academic pathways among TVET teachers and leaders are significant constraints. Moreover, the high percentage of neutral responses to questions about employment opportunities, programme relevance, educational prospects, and salary expectations indicates a lack of information about TVET, rather than opposition to it, among students. This suggests that information gaps and misconceptions may affect students' educational and career choices.

Therefore, raising awareness, providing career guidance, and exposing students to TVET and Hi-TVET opportunities at an early stage should be key priorities in strengthening the image and attractiveness of TVET. Improved coordination between schools, industry, and TVET institutions is needed to ensure that students receive accurate information on career pathways, employability, and TVET-to-work routes. By addressing misconceptions and highlighting the relevance of TVET to Industry 4.0 and future workforce needs, stakeholders can help attract more learners to TVET programmes and develop a highly skilled workforce to support national economic and technological development.

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