

# Talent Intelligence in TVET Work-Based Learning: A Quantitative Analysis of Creative Problem Solving and Technological Literacy

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**Abstract:** *This study investigates the level of Talent Intelligence among Bachelor of Technology students at Universiti Tun Hussein Onn Malaysia (UTHM) within the framework of Work-Based Learning (WBL), with particular emphasis on two key constructs: Creative Problem Solving and Technological Literacy. Anchored in the demands of Industry 4.0, the study aligns with national aspirations to develop future-ready Technical and Vocational Education and Training (TVET) graduates. A quantitative research design was employed using a stratified random sampling technique involving 149 students from three faculties. The research instrument underwent expert validation and demonstrated high reliability (Cronbach's alpha > 0.90). Descriptive findings revealed high mean scores for both constructs (Creative Problem Solving = 4.13; Technological Literacy = 4.19), indicating a strong level of Talent Intelligence among the respondents. Inferential analysis using the Mann-Whitney U test showed a statistically significant gender difference in Creative Problem Solving, while no significant difference was identified for Technological Literacy. The findings underscore the effectiveness of WBL in enhancing both cognitive and digital competencies among TVET students. However, the study highlights the need for continuous curricular enhancement to strengthen creativity, integrate industry-relevant digital skills, and ensure inclusive learning practices. Future research is recommended to adopt mixed method approaches to provide a more comprehensive understanding of Talent Intelligence development across diverse learner profiles.*

**Keywords:** Talent Intelligence, Work-Based Learning, Creative Problem Solving, Technological Literacy, TVET, IR 4.0

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## 1. Introduction

The advent of the Fourth Industrial Revolution (IR 4.0) has significantly reshaped global socio-economic structures and educational systems, creating an urgent demand for a workforce that is not only technically competent and digitally skilled but also creatively adaptive (Mazlan et al., 2025a). In response to these transformations, Malaysia has introduced various national initiatives, such as the National TVET Policy 2030 and the Malaysian Higher Education Action Plan 2022–2025, aimed at producing future-ready graduates through the enhancement of

Technical and Vocational Education and Training (TVET) pathways (Ahmad & Nasir, 2024; MTVET, 2030; Mazlan et al., 2025b). Within this context, Work-Based Learning (WBL) has emerged as a key pedagogical approach, recognised for its effectiveness in bridging theoretical knowledge with authentic industry practice, thereby ensuring that educational outcomes remain aligned with labour market demands (Mohd Yusoff et al., 2025; Mazlan et al., 2025c; Bahrum et al., 2025). Furthermore, this approach supports broader global agendas, particularly the Sustainable Development Goals (SDGs), including SDG 4 (Quality Education) and SDG 8 (Decent Work), as well as regional frameworks such as the ASEAN Mutual Recognition Arrangements (SEA-VET, 2024; ILO, 2024).

As industries increasingly accelerate the adoption of automation, artificial intelligence (AI), the Internet of Things (IoT), and sustainable technologies, higher education institutions are required to prepare students to understand, adapt, and innovate within these evolving environments. Reports by UNESCO and UNESCAP highlight the critical need to align TVET systems with rapidly advancing industrial technologies to ensure graduate relevance and employability (Amin et al., 2023; UNESCO, 2023; Mazlan et al., 2025d). In this regard, WBL serves as an effective mechanism for such alignment by immersing students in authentic workplace contexts, thereby facilitating the development of practical competencies alongside entrepreneurial, digital, and sustainability-oriented values (Wickramasinghe & Wickramasinghe, 2024; The Future of Jobs Report, 2025). Despite relatively encouraging employability outcomes among graduates of polytechnics and community colleges, notable disparities remain, particularly in relation to the employability of female graduates and their participation in technical fields (Ros & Nazren, 2021; Masud et al., 2018).

In the context of IR 4.0, employability is fundamentally reflected through the notion of Talent Intelligence, which in this study is conceptualised through two interrelated dimensions: Creative Problem Solving and Technological Literacy. These dimensions represent an integration of inherent capabilities and acquired competencies that are essential for addressing complex industrial challenges. The Creative Problem Solving (CPS) framework, originally introduced by Osborn and Parnes and later enhanced by scholars such as Isaksen and Treffinger, provides a structured approach to innovation involving stages such as problem clarification, idea generation, and solution implementation (Cheruvath & Chandrakant, 2024). Meanwhile, technological literacy refers to an individual's capacity to effectively access, evaluate, and apply digital technologies, as emphasised in frameworks such as the ISTE Standards (2016). Collectively, these competencies are increasingly critical, as modern industries demand a workforce capable of integrating creativity, innovation, and technical expertise in a cohesive manner (Shahran, 2024; Ngatiman et al., 2023).

Malaysian graduates often encounter challenges in mastering advanced digital technologies as well as key soft skills, including communication, adaptability, and critical thinking (Bassah & Noor, 2023; Yaakob et al., 2020). Such limitations contribute to lower employability levels and reduced earning potential, particularly among TVET graduates (Aziz & Subramaniam, 2023). In addition, female graduates remain underrepresented in many technical fields, which may limit their opportunities to acquire industry-relevant competencies (Emah et al., 2025). Although WBL is intended to bridge the gap between academic knowledge and industrial practice, its implementation in Malaysia remains uneven. This inconsistency is largely attributed to unclear standards, weak collaboration between educational institutions and industry, and limited engagement from key stakeholders (Moo, 2024; Z. Ibrahim et al., 2019). An increasing concern is the insufficient integration of digital competencies within TVET curricula, particularly in areas such as cloud computing, data analytics, and machine learning

(Ali et al., 2024; Yaakob et al., 2020). This limitation is partly attributed to weak collaboration between educational institutions and industry, which restricts the provision of relevant and practical training opportunities (Adam et al., 2020; Kamarulzalis, 2024). At the same time, existing studies indicate that WBL can more effectively develop both technical and human competencies when students are exposed to authentic and interdisciplinary learning environments (Hartati & Giovanni, 2022; Yusof et al., 2020). Gender also plays a role in shaping these learning outcomes, where male students tend to demonstrate stronger technical performance, while female students often exhibit greater strengths in communication and leadership skills (Siddiky, 2020; Ismail et al., 2017).

Although previous studies have explored the overall effectiveness of WBL in enhancing student competencies, limited attention has been given to the development of specific talent domains such as Creative Problem Solving and Technological Literacy. Furthermore, much of the existing literature relies on qualitative approaches or quasi-experimental designs, which may not adequately capture the broader quantitative patterns required to inform curriculum improvement. There remains a significant gap in empirically evaluating the effectiveness of WBL in cultivating these critical competencies within the context of Malaysian higher education, particularly in relation to gender-based differences in skill acquisition. Consequently, a comprehensive and data-driven investigation is essential to assess the current level of Talent Intelligence among technology students and to guide institutional strategies toward more adaptive, evidence-based, and inclusive educational practices.

This study aims to assess the level of Talent Intelligence, with a particular focus on Creative Problem Solving and Technological Literacy, among Bachelor of Technology students engaged in WBL programmes at Universiti Tun Hussein Onn Malaysia (UTHM). In addition, the study examines the presence of significant gender-based differences in the mastery of these competencies. The findings are expected to provide meaningful insights for higher education institutions, industry stakeholders, and policymakers in strengthening curriculum development, enhancing industry collaboration, and formulating strategic initiatives to better prepare graduates for the demands of the IR4.0 landscape.

## **2. Literature Review**

Talent Intelligence in the 21st-century learning context is increasingly viewed as a multidimensional construct encompassing cognitive, emotional, and technological competencies. It reflects an individual's ability to apply innate talents in tandem with acquired skills to effectively solve complex problems and adapt to evolving environments. Within the TVET framework, Talent Intelligence contributes significantly to graduate employability and industrial readiness, especially in the wake of digital transformation under IR 4.0 (Ahmad & Nasir, 2024). Goleman's concept of intelligence that integrates emotional and adaptive capacities serves as a foundational perspective in understanding how Talent Intelligence can be cultivated through formal education and experiential learning structures.

### **2.1 Creative Problem Solving in context of TVET**

Creative Problem Solving (CPS) is an essential competency in TVET, allowing students to tackle industry issues through imaginative and analytical reasoning. The CPS approach, derived from the Osborn-Parnes model and further refined by Isaksen and Treffinger, encompasses five stages: clarification, ideation, development, and implementation. These processes are essential for fostering advanced cognitive skills and innovative strategies for practical tasks (Cherualath & Chandrakant, 2024). In TVET settings, CPS fosters autonomy,

adaptability, and resilience qualities essential for navigating uncertainty and facilitating innovation in the workplace (Ngatiman et al., 2023; Amin et al., 2023). Experiential learning that includes genuine industrial tasks, especially in project-based and work-based settings, has demonstrated an enhancement in students' capacity for innovative thinking amid uncertainty. When learners participate in open-ended assignments with industry mentorship, they develop both technical skills and the ability to conceptualise, test, and refine innovative solutions.

## **2.2 Technological Literacy as a Core Competency**

Technological literacy is the capacity to access, assess, and utilise digital technologies proficiently. This ability has become a vital component of student success in TVET programmes, especially in equipping graduates for IR 4.0 situations where proficiency in digital technologies like cloud platforms, IoT systems, and AI is crucial. Frameworks such as the ISTE Standards (2016) delineate fundamental indications of digital preparedness, encompassing computational thinking, digital citizenship, and innovative communication through technology. Notwithstanding its significance, several TVET institutions continue to have difficulties in incorporating adequate digital exposure into their curricula (Ali et al., 2024; Yaakob et al., 2020). Inadequate access to modern digital tools and insufficient curriculum alignment have led to discrepancies between graduate competencies and industry expectations. Technological literacy must be cultivated alongside cognitive and interpersonal skills to adequately equip students for dynamic work environments that necessitate cross-functional digital involvement.

## **2.3 Work-Based Learning and the Development of Talent**

WBL effectively cultivates industry-relevant skills by bridging academic theory with practical practice. By engaging with real-world situations, students can enhance their problem-solving abilities, develop digital proficiency, and foster adaptability in the workplace. WBL promotes experiential education, augments reflective cognition, and cultivates employability via mentor-led initiatives and cooperative assignments (Hartati & Giovanni, 2022; Wickramasinghe & Wickramasinghe, 2024). The use of WBL in TVET programs enhances the whole development of learners by strengthening both technical skills and interpersonal abilities. It increases engagement and motivation by imparting relevance and purpose to classroom instruction. The efficacy of WBL is contingent upon robust institutional-industry collaborations and well-defined learning outcomes that correspond with occupational competencies (Z. Ibrahim et al., 2019; Moo, 2024). When effectively executed, WBL may substantially enhance Talent Intelligence by engaging students in real-time problem-solving and digital contexts.

## **2.4 Gender Differences in Skill Acquisition**

Gender continues to be a crucial determinant affecting the advancement of cognitive and technical skills in TVET. Studies reveal that male students frequently exhibit greater confidence and success in technical disciplines, whereas female students thrive in communication and emotional intelligence areas (Ismail et al., 2017; Siddiky, 2020). These disparities are influenced by a confluence of cultural expectations, educational background, and self-efficacy in technological utilisation (Ros & Nazren, 2021; Masud et al., 2018). Rectifying this disparity necessitates comprehensive curriculum development and fair access to practical digital and problem-solving opportunities. Gender-sensitive pedagogical practices in WBL such as focused mentoring, inclusive project responsibilities, and equitable assessment design can mitigate the skill gap and improve the overall development of Talent Intelligence among student populations.

## 2.5 Adaptation to Change as Theoretical Framework

This study utilises the Theory of Adaptation to Change to analyse how students adapt to evolving technological environments and professional demands. The theory emphasises humans' ability to observe, evaluate, and react to internal and external changes, especially in uncertain and complicated contexts. Talent Intelligence exemplified by CPS and Technological Literacy serves as both a metric of aptitude and a result of effective adaptation (Shahran, 2024; Emah et al., 2025). Embedding WBL inside this theoretical framework enables educators and researchers to more effectively evaluate how students internalise adaptive behaviours and apply their learning in unpredictable, real-world circumstances. The cultivation of adaptable learners is a strategic necessity for TVET institutions aiming to synchronise their outcomes with national development objectives and international industry benchmarks. The literature study highlights the essential importance of Talent Intelligence, which includes Creative Problem Solving and Technological Literacy, in developing future-ready TVET graduates. WBL provides a feasible avenue for developing these competencies; nevertheless, its efficacy depends on appropriate execution, curricular integration, and inclusive methodologies. Notwithstanding the increasing interest in Talent Intelligence, less empirical research has investigated its evolution through WBL in the Malaysian context, especially concerning gender disparities. This study examines the degrees and variances of Talent Intelligence among UTHM Bachelor of Technology students participating in structured WBL activities.

## 3. Methodology

This study employed a survey method using a quantitative research design. The approach was deemed suitable for assessing the level of Talent Intelligence among Bachelor of Technology students who are engaged in WBL at UTHM. According to Nardi (2018), survey-based research is appropriate for examining respondents' perceptions and competencies in a structured and generalisable manner.

### 3.1 Research Sample

A total of 149 students from three different faculties, the Faculty of Technical and Vocational Education (FPTV), the Faculty of Engineering Technology (FTK), and the Faculty of Mechanical & Manufacturing Engineering (FKM) in UTHM, who were undergoing the WBL program, participated in this study. All students received a structured questionnaire. Out of the total number of respondents, 96 were male and 53 were female. Table 1 presents the distribution of respondents by gender.

**Table 1: Respondents by gender**

Gender	Frequency ( <i>f</i> )	Percentage (%)
Male	96	64.4
Female	53	35.6
Total	149	100.0

### Guidelines for Submission of Article

As part of the submission process, authors are required to check all of the following items, as submissions may be returned to authors that do not adhere to these guidelines.

In this study, a structured questionnaire was used as the main data collection instrument. The items were developed based on established constructs and measured using a four-point semantic differential scale, ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). The

questionnaire was divided into three main parts, comprising demographic information, Creative Problem Solving, and Technological Literacy.

A total of 21 items were used to measure students’ Creative Problem-Solving ability. Sample items include: “I am able to evaluate the effectiveness of the solution” and “I take responsibility for each decision made during problem-solving”. These items reflect the extent to which students demonstrate innovation, analytical thinking, and confidence in resolving challenges. To assess students’ Technological Literacy, another 21 items were employed. Example items include: “I use technology to facilitate learning effectively” and “I am skilled in applying digital tools and platforms in my learning process”. These items aim to capture students’ ability to adapt to and utilize digital technologies in line with the demands of IR4.0 and industry expectations.

Before the actual study was conducted, the validity of the instrument was established through expert validation. Three subject matter experts from the field of TVET and educational measurement were invited to review the content and clarity of the questionnaire items. Revisions and refinements were made based on the feedback and recommendations provided by the experts.

The reliability of the instrument was confirmed through a pilot study involving 30 students. The internal consistency analysis showed a high level of reliability, with Cronbach’s Alpha values of 0.951 for Creative Problem Solving and 0.925 for Technological Literacy, both of which are considered highly acceptable for social science research. The reliability levels are shown in Table 2.

**Table 2: Reliability levels**

Variable	Reliability Level
Creative Problem-Solving	0.951
Technological Literacy	0.925
Total	0.934

## 4. Results

A total of 149 completed questionnaires were collected through the Google Form application. The collected data were analyzed to answer the research questions concerning variables such as Creative Problem Solving and Technological Literacy, which represent key components of Talent Intelligence. The data analysis involved the use of descriptive statistics and inferential statistics for hypothesis testing. The results of the study are presented in the form of mean values and standard deviations.

### 4.1 Analysis of constructs Talent Intelligence: Creative Problem-Solving and Technological Literacy among Bachelor of Technology students

Table 3 shows the overall descriptive analysis showing mean value, standard deviation and level of agreement for each variable which is Creative Problem-Solving and Technological Literacy. The results show that the mean score of Creative Problem-Solving and Technological Literacy is 4.131(SD=0.5639), and 4.186(SD=0.5642) respectively. These findings suggest that the level of Talent Intelligence among TVET students undergoing WBL is high in both dimensions.

**Table 3: Mean value for variables**

Variable	Mean	Standard Deviation (SD)	Level of Agreement
Creative Problem-Solving	4.131	0.5639	High
Technological Literacy	4.186	0.5642	High

#### 4.2 Inferential analysis of the level of Talent Intelligence in terms of Creative Problem Solving and Technological Literacy among Bachelor of Technology students based on gender

The results obtained in Table 4 address the third research question by conducting inferential analysis to identify differences in the level of Talent Intelligence specifically in Creative Problem Solving and Technological Literacy based on gender. Since the normality test indicated that the data were not normally distributed, the non-parametric Mann-Whitney U test was employed.

**Table 4: Analysis of Mann-Whitney U test according to aspects based on gender groups**

Test	Creative Problem-Solving	Technological Literacy
Mann-Whitney U	1964.000	2274.500
Wilcoxon W	3395.000	3705.500
Z	-2.302	-1.070
Asymp. Sig. (2-tailed)	<b>0.021</b>	<b>0.285</b>

Findings from the Mann-Whitney U test revealed a statistically significant difference in the level of Creative Problem Solving between male and female students, with a p-value of 0.021 ( $p < 0.05$ ). The mean rank for male students (81.04) was higher than that of female students (64.06), indicating that male students demonstrated a higher level of creative problem-solving skills. Therefore, the null hypothesis ( $H_0$ ) was rejected for this variable, confirming a significant difference between genders. Although a significant difference was found in Creative Problem Solving, the effect size should be considered. Using the formula  $r = Z/\sqrt{N}$ , the effect size was calculated as  $r = -2.302/\sqrt{149} \approx -0.19$ , which indicates a small effect (Cohen, 1988). On the other hand, for the Technological Literacy construct, the Mann-Whitney U test results showed no statistically significant difference between male and female students ( $p = 0.285 > 0.05$ ). Although the mean rank for male students (77.31) was higher than that of female students (69.92), the difference was not statistically significant. Therefore, the null hypothesis ( $H_0$ ) was accepted for this variable, indicating no significant gender difference in terms of technological literacy.

Overall, the analysis indicates that there is a significant gender-based difference in Creative Problem Solving in favour of male students, while no significant difference exists between male and female students in Technological Literacy.

#### 4.3 Discussion

Section 4.3 discusses the findings related to Talent Intelligence among Bachelor of Technology students within the context of WBL. Specifically, this section examines the level of Talent Intelligence in terms of Creative Problem Solving and Technological Literacy, as well as the differences in these competencies based on gender. The discussion is structured into three subsections to provide a comprehensive interpretation of the results in relation to existing theories and empirical studies.

### 4.3.1 Level of Talent Intelligence in Terms of Creative Problem Solving Among Bachelor of Technology Students

Overall, the average mean score for Talent Intelligence in Creative Problem Solving was determined to be high, ranging from 3.68 to 5.00. This construct was delineated into six subdimensions to evaluate students' competencies in Creative Problem Solving: problem identification, information collection, idea generation, solution development, support acquisition, and plan implementation. The components utilised in this design were derived from Chaiyarat (2024), who delineated elements of Creative Problem Solving according to the Alex Osborn and Sid Parnes framework.

According to Table 4.7, the total mean score for this feature was 4.13, with a standard deviation of 0.5639, signifying a high degree of perception. All 21 items exhibited elevated levels of Talent Intelligence, with mean scores varying from 3.85 to 4.54. This indicates that pupils had a robust capacity to recognise issues, seek assistance, and formulate solutions to the obstacles they face. These findings correspond with Zakiyah et al. (2024), who highlighted that critical thinking is intrinsically linked to creative problem solving, as students possessing robust critical thinking skills can analyse phenomena and facts while formulating coherent arguments and reasoning to substantiate their ideas. Fatmawati et al. (2022) emphasised that creative thinking is fundamental to issue solving, as it encompasses an individual's capacity to formulate ideas devoid of the limitations of correct or incorrect responses.

This study demonstrates that WBL creates an effective environment for enhancing Talent Intelligence in Creative Problem Solving. This is shown in students' ability to recognise issues and produce innovative and feasible solutions. Nevertheless, several elements received low scores within the high category, especially those pertaining to idea development and securing support. Despite being in the elevated range, these results indicate that a portion of students persist in encountering difficulties in developing creative problem-solving abilities, especially in generating ideas using brainstorming methods.

Isaksen (2023) observed that brainstorming in the preliminary phase may impede individuals' innovative thinking. Osborn contended that brainstorming is designed not to constrain creativity but to promote collaborative idea generation. Duyver et al. (2023) created an assessment instrument to evaluate creativity in computer science students, highlighting aspects such as critical thinking, communication, curiosity, and the application of creative methodologies. Their findings confirm that these skills can be methodically evaluated and cultivated in higher education. This corroborates the current study, which discovered that WBL facilitates students in demonstrating many facets of creativity through practical projects. The intricacy of WBL activities enables students to cultivate profound patterns of creative thought and reflective understanding.

From an alternative viewpoint, the results offer significant insight into the efficacy of WBL in fostering the advancement of Talent Intelligence, especially in Creative Problem Solving. Although the overall scores were elevated, it is crucial not to depend exclusively on the figures; rather, a more profound analysis of the background and ramifications should be undertaken. For example, marginally reduced mean scores on certain items suggest potential for enhancement in students' capacity to produce ideas and secure social support during problem-solving activities. This may indicate deficiencies in the application of WBL, where systematic ideation methods (e.g., brainstorming) or persuasive communication abilities may not have been thoroughly integrated.

Consequently, it is advisable to reassess instructional design in WBL to guarantee an equitable focus on creative thinking, self-reflection, and collaborative skills. These implications are essential for ensuring that students master technical competencies while also cultivating cognitive flexibility and the confidence to question norms in generating new, industry-relevant solutions.

#### **4.3.2 Level of Talent Intelligence in Terms of Technological Literacy Among Bachelor of Technology Students**

The analysis of 21 items indicated an overall mean score exceeding 3.67, reflecting a high level of Technological Literacy among the respondents. This construct was assessed across several key components, namely Technological Knowledge, Technological Usage, Technological Skills, and awareness of Technology Ethics and Safety. Notably, eighteen items recorded mean scores above 4.00, particularly within the domains of technological usage and ethical awareness, suggesting that students possess a solid understanding of industry-relevant technologies and demonstrate adaptability to emerging technological developments.

These findings are consistent with Yaacob et al. (2024), who emphasised that strong proficiency in technology use, coupled with ethical awareness, enables students to make informed decisions, protect their digital identity, and participate responsibly in digital environments. Such competencies allow learners to utilise modern technologies effectively while minimising associated risks, thereby enhancing both safety and efficiency in digital engagement.

Further support is evident in previous studies. Chan and Sung (2025) reported that course-based projects significantly enhance digital literacy, particularly in accessing, managing, evaluating, and producing information through digital platforms. This aligns with the present study, which highlights the role of WBL in promoting the use of technology as both a cognitive and practical learning tool. Similarly, Nantha et al. (2024) found that the integration of TPACK-based blended learning approaches improved ICT literacy by more than 80% among students, reinforcing the importance of embedding technology within instructional design. These findings collectively support the effectiveness of WBL as an integrative model that combines learning and workplace experience to enhance technological competencies.

Despite the overall high performance, two items knowledge related to the IoT and Cloud Computing recorded comparatively lower mean scores, indicating areas for improvement. While students demonstrated competence in utilising existing technologies, their exposure to advanced and emerging technologies remains limited. Ismail and Hassan (2019) highlighted that exposure to such technologies is crucial in developing digital adaptability, particularly within technical and engineering disciplines.

From a theoretical perspective, the findings align with Vygotsky's Constructivist Theory, which posits that learning occurs most effectively through active engagement in authentic contexts. WBL facilitates this process by integrating real-world technological applications, enabling students to develop their knowledge through experiential learning. The high level of technological competence observed in this study underscores the effectiveness of WBL in fostering technological capability. However, greater emphasis on emerging technologies is necessary to ensure that graduates remain competitive in an increasingly complex and technology-driven labour market (Ismail & Hassan, 2019).

### 4.3.3 Differences in Talent Intelligence in Terms of Creative Problem Solving and Technological Literacy Among Bachelor of Technology Students Based on Gender

Inferential analysis using the Mann-Whitney U test, as reported in Table 4, revealed a statistically significant gender difference in Talent Intelligence within the Creative Problem-Solving domain. Male students recorded a higher mean rank ( $M = 81.04$ ) compared to female students ( $M = 64.06$ ), with a p-value of 0.021 ( $p < 0.05$ ), leading to the rejection of the null hypothesis. This result indicates that male students in the Bachelor of Technology programme demonstrate relatively stronger creative problem-solving abilities within the WBL context.

This outcome is supported by He and Wong (2021), who found that male students in engineering and technology fields tend to exhibit greater risk-taking behaviour and are more inclined toward spontaneous experimentation, contributing to stronger divergent thinking and creative problem-solving performance. Similarly, Emah et al. (2025) highlighted that early exposure to technical and logic-based activities, along with socio-cultural influences, may advantage male students in developing such competencies. However, based on Cohen's (2013) guideline, the calculated effect size ( $r = -0.19$ ) indicates a small effect, suggesting that although the difference is statistically significant, its practical impact remains limited.

From a theoretical perspective, this finding aligns with Gender Differences Theory proposed by Maccoby and Jacklin (1974), which posits that gender variations may exist in certain cognitive domains, including creativity and problem-solving. Nevertheless, contemporary research suggests that such differences are context-dependent and may vary across disciplines and learning environments (He & Wong, 2021). Supporting this view, Otero et al. (2024) also reported that males tend to score slightly higher in creativity, although the magnitude of difference is generally small.

In contrast, the analysis of Technological Literacy revealed no statistically significant gender difference ( $p = 0.285 > 0.05$ ), despite male students having a slightly higher mean rank (77.31) compared to female students (69.92). This finding suggests that technological competencies are relatively balanced across genders. It is consistent with Awang et al. (2021), who reported that the gender digital divide in higher education is narrowing, largely due to increased access to and exposure to digital technologies.

Overall, the findings indicate that while gender differences are evident in creative problem-solving, technological literacy demonstrates more equitable outcomes. This underscores the need for targeted instructional strategies aimed at enhancing creative problem-solving skills, particularly among female students, to strengthen Talent Intelligence and improve employability in the technology sector. Although the observed effect size is small, the results highlight the importance of adopting gender-responsive and inclusive pedagogical approaches. The absence of significant gender differences in technological literacy further suggests that both male and female students are equally capable of adapting to rapid technological advancements. While WBL appears to foster a relatively inclusive learning environment, further pedagogical refinement is necessary to better support the development of creative potential among all learners, ensuring that Talent Intelligence is cultivated in an equitable and comprehensive manner.

## 5. Conclusion

The findings demonstrate that the Work-Based Learning (WBL) approach effectively enables the application of theoretical knowledge within authentic workplace settings, thereby

enhancing students' professionalism, technological competence, and soft skills. The study identified a significant gender difference in Creative Problem Solving, while Technological Literacy showed no substantial variation between male and female students. Practical recommendations were proposed for students, educators, industry stakeholders, and future researchers to strengthen the implementation and overall effectiveness of WBL programmes. In this regard, the study reinforces the role of WBL as a key strategy in higher education for aligning academic preparation with industry demands and fostering holistic student development.

Furthermore, the results indicate that the integration of WBL contributes to the improvement of technical competencies and the enhancement of Talent Intelligence among Bachelor of Technology students, particularly in the domains of Creative Problem Solving and Technological Literacy. The high levels observed in both constructs support the positioning of WBL as a strategic pedagogical approach within technical and vocational higher education. This study offers valuable contributions in terms of theoretical advancement, practical implementation, policy formulation, and future research directions. Specifically, it extends the application of the Creative Problem Solving (Osborn–Parnes) model within the WBL context and incorporates constructivist perspectives to better understand learning processes in authentic and meaningful environments.

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### **Conflict of Interest Statement**

The authors declare that there is no conflict of interest regarding the publication of this study.

### **References**

- Adam, S., Baharuddin, S. A., Mustaffa, N., & Mohd Noor, S. N. F. (2020). Kesan pembelajaran berasaskan kerja terhadap pelajar Kolej Vokasional. *Persidangan Antarabangsa Sains Sosial dan Kemanusiaan*.
- Ahmad, N. F., & Nasir, R. (2024). Strategi pembangunan pendidikan tinggi melalui dasar TVET Negara 2030. *Jurnal Pendidikan Malaysia*, 49(1), 22–31.
- Ali, N., Ibrahim, N. H., & Muda, R. (2024). Integrating IoT in TVET curricula: Challenges and opportunities. *International Journal of TVET Studies*, 6(1), 45–55.
- Amin, M., Lee, J., & Singh, R. (2023). *UNESCAP Report on Skills Development and the Fourth Industrial Revolution in Asia-Pacific*. United Nations ESCAP.
- Awang, M. M., Zubir, M. Z. A., & Abdullah, M. S. (2021). Tahap literasi digital pelajar institusi pengajian tinggi semasa PdPR. *Jurnal Pendidikan Malaysia*, 46(2), 20–33.
- Aziz, N., & Subramaniam, S. (2023). Gender gaps in TVET employability: A Malaysian case study. *ASEAN Journal of Technical Education*, 9(2), 65–77.
- Bahrum, M. I. H., Puteh, S., Mazlan, M. H., Sulaiman, N. L., Salleh, K. M., & Buhari, R. (2025). Embedding Web-Based Learning into Industry 4.0-Oriented TVET: Strengthening Future Workforce Competencies. *International Journal of Advanced Research in Education and Society*, 7(5), 372–384. <https://doi.org/10.55057/ijares.2025.7.5.32>
- Bassah, N. B., & Noor, H. A. M. (2023). Employability skills among vocational students: Perspectives from industry. *TVET Global Journal*, 8(3), 112–120.

- Chaiyarat, R. (2024). Creative problem-solving skills and innovation competency among engineering students. *Journal of Technical Education and Training*, 16(1), 55–67.
- Chan, L. H., & Sung, Y. H. (2025). Enhancing digital literacy through course-based projects in higher education. (Pending journal/publisher details)
- Cherualath, R., & Chandrakant, K. (2024). Creativity in problem-solving: Educational perspectives from South Asia. *Educational Thought Journal*, 7(2), 85–99.
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge.
- Duyver, M., Stender, V., & Tan, Y. (2023). Measuring creativity among computer science students: Development of an assessment tool. *Computers & Education*, 195, 104701. <https://doi.org/10.1016/j.compedu.2023.104701>
- Emah, I., Abdul Rahim, A., & Latip, N. (2025). Underemployment among female TVET graduates in Malaysia. *Southeast Asian Social Research Journal*, 11(1), 19–33.
- Fatmawati, N., Mohd Nor, M. Z., & Zulkifli, R. (2022). Creative thinking as the foundation of problem-solving in TVET curriculum. *International Journal of TVET Studies*, 10(2), 45–60.
- Hartati, N., & Giovanni, R. (2022). Work-based learning and student employability: Evidence from Indonesia. *Journal of Asian Vocational Education*, 4(4), 36–50.
- He, Q., & Wong, L. M. (2021). Gender differences in risk-taking and divergent thinking among engineering undergraduates. *Journal of Engineering Education*, 110(3), 554–569.
- ILO. (2024). *ASEAN Skills Strategy and Mutual Recognition Arrangements Report*. International Labour Organization.
- Isaksen, S. G. (2023). Revisiting brainstorming: Collaboration and creativity in early ideation. *Creativity Research Journal*, 35(1), 12–25.
- Ismail, N., Hassan, R., & Jamaludin, N. (2017). Kecenderungan pelajar lelaki dan perempuan dalam penguasaan bidang teknikal. *Jurnal Psikologi Pendidikan dan Kaunseling*, 6(2), 77–86.
- ISTE. (2016). *ISTE Standards for Students*. International Society for Technology in Education. <https://www.iste.org/standards/iste-standards-for-students>
- Kamarulzalis, K. (2024). TVET curriculum integration of AI and cloud systems: An exploratory study. *Malaysian Journal of Digital Education*, 3(1), 18–29.
- Maccoby, E. E., & Jacklin, C. N. (1974). *The psychology of sex differences*. Stanford University Press.
- Masud, M. M., Ibrahim, M. D., & Yaacob, A. R. (2018). Women participation in technical education in Malaysia: Barriers and strategies. *Journal of Women and Development*, 5(2), 22–31.
- Mazlan, M. H., Puteh, S., Bahrum, M. I. H., Mohamad, Z., Sulaiman, N. L., Mohd Salleh, K., Wan Omar, W. R., Buhari, R., & Mp, H. (2025a). Validation of an IR4.0 talent framework for TVET students using principal component analysis in work-based learning. *Higher Education, Skills and Work-Based Learning*, 1–18. <https://doi.org/10.1108/HESWBL-07-2025-0298>
- Mazlan, M. H., Puteh, S., Mohamad, Z., Sulaiman, N. L., Salleh, K. M., Omar, W. R. W., Buhari, R., & Mp, H. (2025b). Crafting the future workforce: A Fleiss Kappa exploration of Industry 4.0 talent perspectives. *Higher Education, Skills and Work-Based Learning*, 15(3), 576–594. <https://doi.org/10.1108/HESWBL-05-2024-0145>
- Mazlan, M. H., Puteh, S., Sulaiman, N. L., Salleh, K. M., & Mohamad, Z. (2025c). The Domains and Components of Industry 4.0 Talent for TVET Students Through Work-Based Learning. *Journal of Technical Education and Training*, 17(3), 106–117. <https://doi.org/10.30880/jtet.2025.17.03.008>
- Mazlan, M., Puteh, S., Sulaiman, N., Mohd Salleh, K., Mohamad, Z., & Rosemehah, W. (2025d). Enhancing Malaysian Polytechnic Graduates' Employability in the ASEAN

- Workforce through Work-Based Learning for Industry 4.0. 7, 443–457. <https://doi.org/10.55057/ijares.2025.7.5.36>
- Mohd Yusoff, N. Z., Puteh, S., Mazlan, M. H., Mohamad, Z., Ngah, A. H., Khairudin, Moh., & Buhari, R. (2025). Exploring self-efficacy in WBL programmes: A case study from Universiti Tun Hussein Onn Malaysia and its global implications for TVET. *Higher Education, Skills and Work-Based Learning*, 1–16. <https://doi.org/10.1108/HESWBL-01-2025-0013>
- Moo, S. C. (2024). Guidelines and gaps in WBL implementation in Malaysian universities. *Journal of Higher TVET*, 5(1), 99–108.
- MTVET. (2020). *Dasar TVET Negara 2030*. Kementerian Sumber Manusia Malaysia.
- Nantha, K., Lim, H. T., & Zainal, N. A. (2024). Integrating TPACK in blended learning to enhance ICT literacy. *Asian Journal of Educational Technology*, 9(1), 22–36.
- Ngatiman, N., Abdul Wahab, J., & Mustapha, R. (2023). Technological adaptation and curriculum readiness in Malaysian TVET institutions. *TVET Review Malaysia*, 11(2), 43–59.
- Otero, J., Linares, M., & Xu, W. (2024). Small gender differences in creativity scores: A cross-cultural study. *Psychology of Aesthetics, Creativity, and the Arts*, Advance online publication. (Pending DOI)
- Ros, M. R., & Nazren, A. (2021). TVET graduate employability in Malaysia: Trends and gender perspectives. *Journal of Malaysian Labour Market Studies*, 2(1), 55–70.
- SEA-VET. (2024). *Regional review on WBL and mutual recognition in ASEAN*. Southeast Asia Vocational Education and Training Initiative.
- Shahran, A. S. (2024). Industrial collaboration in IR4.0 curriculum: Malaysian TVET perspective. *Industrial Education Journal*, 10(3), 101–113.
- Siddiky, M. R. (2020). Gender disparity in technical education: South Asian insights. *Asian Journal of Gender and Education*, 6(2), 41–53.
- The Future of Jobs Report. (2025). *World Economic Forum Report on Future Skills and Job Trends*. World Economic Forum.
- UNESCO. (2023). *Transforming TVET for sustainable development in Asia-Pacific*. United Nations Educational, Scientific and Cultural Organization.
- Wickramasinghe, W. N., & Wickramasinghe, G. L. (2024). Promoting TVET for green economy and entrepreneurship. *Journal of TVET and Sustainability*, 7(1), 59–72.
- Yaacob, M. A., Ismail, M. S., & Zahari, M. (2024). Etika digital dan kesedaran keselamatan dalam kalangan pelajar TVET. *Jurnal Pendidikan Teknikal dan Vokasional Malaysia*, 18(1), 45–59.
- Yaakob, A., Ibrahim, H., & Ahmad, M. (2020). Digital readiness among TVET lecturers in Malaysia. *Jurnal Pendidikan Teknikal*, 15(1), 27–36.
- Yusof, N., Abd Rahman, R., & Kamal, S. N. (2020). TVET in Industry 4.0 era: Challenges and prospects in Malaysian polytechnics. *Journal of Technical and Vocational Education*, 12(2), 63–75.
- Zakiyah, N., Ahmad, S., & Rahman, N. H. (2024). Critical thinking and creative problem-solving: A correlational study among technical students. *International Journal of Education and Training*, 20(2), 101–115.
- Z. Ibrahim, Z., Hamid, S. R., & Musa, M. (2019). Cabaran pelaksanaan WBL di institusi pengajian tinggi awam Malaysia. *Seminar Kebangsaan Pendidikan Teknik dan Vokasional (TVET)*, 4(1), 99–108.