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Students' Perception of the Effects, Satisfaction, and Challenges of Technology-Enabled Active Learning (TEAL)

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Abstract

This study was conducted to explore students' perceptions of the use of Technology-Enabled Active Learning (TEAL) in teaching and learning at the Faculty of Technical and Vocational Education (FPTV), Universiti Tun Hussein Onn Malaysia. Specifically, the objectives of this study were to identify students' perceptions of the effects of TEAL implementation, satisfaction with TEAL, and the challenges they encountered in TEAL. Additionally, the study aimed to examine whether there were differences in perceptions based on gender across these three aspects. This study employed a quantitative survey design, and data were collected through a questionnaire. The sample consisted of 287 undergraduate students from 14 academic programs at the FPTV. Data were analyzed using descriptive statistics (mean and standard deviation) to address the three research questions and the Mann-Whitney U test to examine gender-based differences. The findings revealed that students' perceptions on the effects of TEAL and satisfaction were at a high level, whereas the perceived challenges were at moderate level. In addition, the result revealed that no significant difference between male and female students in terms of effects, satisfaction, and challenges associated with TEAL. This study suggest that TEAL has the potential to enhance student engagement, understanding, and overall learning satisfaction if implemented systematically and holistically. Therefore, it is recommended that the faculty should strengthen the training related to technology use for both lecturers and students, modernize technology infrastructure, and formulate instructional strategies to create a more interactive and conducive learning environment. These efforts would enable the full optimisation of TEAL in the context of higher education.

1. Introduction

The 21st century has redefined the educational landscape, necessitating students to possess more than just basic literacy and numeracy skills. Graduates today are expected to demonstrate a high level of employability, creativity, and adaptability to meet the demands of a dynamic, technology-driven global economy (Nayan, 2024). In response, many higher learning institutions have emphasised the application of digitalisation in the aspects of governance, research and innovation, and more importantly, in academic delivery.

To align with this transformation, educators are increasingly adopting Technology-Enabled Active Learning (TEAL), an instructional approach that integrates digital tools with active learning strategies. First introduced by John Belcher at the Massachusetts Institute of Technology (MIT) in 2001, TEAL was developed to foster more engaging and interactive learning experiences (Dori & Belcher, 2005). The model combines lectures, collaborative group work, simulations, and hands-on digital resources to encourage student participation, critical thinking, and real-time feedback.

TEAL has gained traction as a promising pedagogical strategy in technical and vocational education settings due to its potential to enhance student motivation, engagement, and knowledge retention (Hassan et al., 2015; Hashim et al., 2023). When effectively implemented, TEAL supports the development of essential soft skills such as collaboration, independence, and digital competence—skills that are vital for future employability (Seethamraju & S. Murthy, 2023). However, while the advantages of TEAL are well acknowledged, its implementation presents significant challenges. Among the barriers identified in past research are instructors limited self-efficacy in using digital tools, lack of creativity in lesson design, and insufficient professional training (Lau & Rosli, 2020; Lim, Jalil, Awang Hidup, & Omar, 2024). Additionally, infrastructural limitations such as rigid classroom layouts and inadequate access to educational technologies hinder the effectiveness of TEAL delivery (Dehdary, Allmark, Al Nadabi, & Al Hurmuzy, 2024, 2024; Abas, 2020). Research shows that classroom layouts that cannot accommodate small group discussions or flexible seating arrangements may inhibit student collaboration and participation, which were two key elements of active learning (Dehdary et al., 2024). When technology-rich pedagogies like TEAL are used in rigid, lecture-style rooms, the potential for dynamic, student-led learning is greatly diminished, further reinforcing the need for institutional support in space planning and instructional design. These constraints are further exacerbated by technical issues such as unstable internet connections and limited availability of digital devices, particularly among students from low-income families (Abd Razak & Rusli, 2022; Francom, 2019).

On the learners' side, varying levels of digital literacy and interest also influence TEAL outcomes. Studies indicate that students who lack motivation or face difficulties in accessing and using technology are less likely to benefit from TEAL environments (Martin et al., 2020; Sánchez et al., 2019). Moreover, some learners struggle with the cognitive load required for multitasking in tech-enhanced classrooms, reducing the overall effectiveness of the learning experience.

A growing body of literature also suggests that gender differences may play a role in shaping perceptions and experiences with TEAL. Male students often exhibit higher self-confidence and a more positive attitude towards technology compared to their female counterparts, which may lead to disparities in participation, satisfaction, and outcomes (Qazi et al., 2022; Tellhed et al., 2023). These differences underline the importance of understanding how gender may influence learners' engagement in digitally enabled student-centred learning environments. Given these existing gaps, this study seeks to explore undergraduate students' perceptions of TEAL at the FPTV, University Tun Hussein Onn Malaysia, from the aspects of the effects of TEAL, satisfaction towards the use of TEAL and the challenges encountered in the TEAL. Apart from that, this study also aimed to determine whether gender-based differences exist in students' perceptions of TEAL implementation.

2. The Basic Concept of TEAL

Technology-Enabled Active Learning (TEAL) is a pedagogical approach that integrates digital technologies with student-centered, active learning strategies to enhance engagement, understanding, and knowledge retention. Moving beyond traditional lecture-based instruction, TEAL emphasizes participation, collaboration, and problem-solving, supported by technological tools that facilitate interactive and immersive learning experiences (Shieh, Chang, & Liu, 2011).

At its core, TEAL shifts the role of the instructor from a knowledge transmitter to a facilitator of learning. Students are encouraged to actively construct knowledge through activities such as group discussions, simulations, case-based learning, and real-time feedback exercises. Digital platforms—such as learning management systems, interactive polling tools, virtual labs, and collaborative applications—enable these activities to occur both inside and outside the classroom, fostering continuous and flexible learning (Dehdary, Allmark, Al Nadabi, & Al Hurmuzy, 2024).

One of the defining features of TEAL is its ability to support diverse learning styles. Visual learners benefit from multimedia content such as videos and animations, while kinesthetic learners engage through simulations and hands-on digital tasks (Oram, 2025). Additionally, TEAL environments often incorporate data analytics to track student progress, allowing instructors to provide personalized feedback and targeted interventions. This adaptability contributes to improved learning outcomes and greater student autonomy.

TEAL is particularly relevant in the context of Technical and Vocational Education and Training (TVET), where practical skills and real-world application are critical (Hassan, Puteh, & Sanusi, 2018). Technologies such as virtual reality (VR), augmented reality (AR), and digital simulations can replicate workplace scenarios, enabling students

to practice skills in a safe and controlled environment (Adi Badiozaman, Segar, & Hii, 2022). This not only enhances technical competence but also builds confidence and readiness for industry demands (Shieh, 2012).

Furthermore, TEAL supports the development of 21st-century competencies, including critical thinking, communication, collaboration, and digital literacy. By engaging students in meaningful tasks and encouraging peer interaction, TEAL prepares learners to navigate complex, technology-driven workplaces. It also aligns with the increasing demand for lifelong learning, as digital tools provide access to continuous education and skill development opportunities (Fisher, 2010).

However, successful implementation of TEAL requires careful planning and support. Institutions must invest in appropriate infrastructure, provide professional development for educators, and ensure equitable access to technology for all students. Without these elements, the benefits of TEAL may not be fully realized.

In conclusion, Technology-Enabled Active Learning represents a transformative approach to education that leverages technology to create dynamic, inclusive, and effective learning environments. By fostering active participation and leveraging digital innovation, TEAL has the potential to significantly enhance teaching and learning across various educational contexts.

2.1 Theoretical Foundation of TEAL

The theoretical foundation of Technology-Enabled Active Learning (TEAL) is primarily grounded in constructivist theory (Sugrah, 2019) and active learning theory (Dehdary et al., 2024), both of which emphasise student-centred learning, active engagement, and knowledge construction. These complementary perspectives provide a strong conceptual basis for understanding how TEAL enhances teaching and learning processes.

From a constructivist perspective, learning is viewed as an active process in which knowledge is constructed by learners rather than passively received. Chuang (2021) highlighted that knowledge is created by the human mind through interaction and experience. In this context, educators play a crucial role in facilitating learning by acknowledging students' prior knowledge, valuing diverse perspectives, and gradually transferring control of the learning process to learners (Sugrah, 2019). TEAL aligns closely with this principle by enabling students to actively explore content using digital tools, engage with learning materials, and apply their understanding to real-world tasks such as developing multimedia outputs and presentations. Furthermore, constructivism emphasises student autonomy and self-directed learning, where learners regulate their own progress and actively seek knowledge (Suryadi, Damopolii, & Rahman, 2022). TEAL supports this by providing a flexible and interactive environment that encourages students to take ownership of their learning through technology.

In parallel, active learning theory reinforces the importance of student participation and responsibility in the learning process. Active learning is defined as an approach where students are directly involved in applying knowledge, developing understanding, and reflecting on their learning (Hung, 2014). Within TEAL environments, this is achieved through the integration of interactive technologies that promote engagement, collaboration, and real-time feedback. Both TEAL and active learning theory advocate a shift from teacher-centred instruction to student-centred learning, where technology serves as a catalyst for participation and knowledge construction (Nicol et al., 2017; Dehdary et al., 2024).

Moreover, active learning theory emphasises the development of higher-order thinking skills, including critical thinking, creativity, and problem-solving. TEAL facilitates these competencies by designing meaningful and interactive learning experiences supported by digital tools (Hassan et al., 2020; Holec & Marynowski, 2020). It also promotes collaboration through online platforms, enabling students to work together, exchange ideas, and co-construct knowledge (Hassan et al., 2018).

In summary, TEAL represents the convergence of constructivist and active learning principles, where technology enhances student engagement, autonomy, and collaboration. By integrating these theoretical perspectives, TEAL creates a dynamic and effective learning environment that supports deep understanding and student success.

2.2 The Effects of Technology-Enabled Active Learning (TEAL)

The study by Zidane and Olsson (2017) defines the term effect as the ability to achieve or produce desired outcomes. More specifically, effect is defined as the achievement of positive results or the successful attainment of intended goals, which is often the subject of academic research (Agbejule & Jokipii, 2009). In this study, effect refers to the extent to which the implementation of Technology-Enabled Active Learning (TEAL) positively contributes to students' learning outcomes and overall learning experiences.

Study by Shi et al. (2020) reported that TEAL is designed to foster learning environments that encourage active learning through technological interaction and engagement in the classroom. Furthermore, technology implementation that focuses on individual use shows greater positive effects on students' cognitive learning. These findings are consistent with subsequent research; for example, Wijaya (2023) concluded through a systematic study that the integration of technology enhances active learning, improves understanding during self-directed learning, and broadens students' digital literacy skills.

Other observed effects include increased student productivity through technology use, enabling learners to evaluate knowledge efficiently, manage their own learning pace more effectively, and exert greater control over the technologies they use (Van et al., 2021). Additionally, Van et al. (2021) identified active participation, effective teaching, and the development of technical skills as key advantages of learning through the TEAL approach in their study on its impact on student engagement and educational experiences. However, its effectiveness depends on students' discipline and how well the technology aligns with course content and supports collaboration. This highlights the importance of evaluating the effectiveness of TEAL, particularly regarding its practical usefulness among students in technical universities (Zalat et al., 2021).

2.3 Satisfaction in the Use of Technology-Enabled Active Learning (TEAL)

Karataş and Şimşek (2009) define satisfaction as the happiness derived from receiving a service. This aligns with the definition by Saif (2014), who states that satisfaction generally refers to the feeling of contentment or joy experienced after completing a task or receiving something desired. In this study, satisfaction is measured based on students' enjoyment, motivation, and engagement while using technology to support active learning in their academic studies. This definition corresponds with the concept of student satisfaction proposed by Pandita and Kiran (2023), which refers to the extent to which students feel happy, fulfilled, and satisfied with their educational experiences.

Findings from Sun et al. (2018) reported that the use of technology for educational purposes improves academic achievement by fostering active learning as a whole. This is achieved through the encouragement of student engagement within a technology-supported learning environment. Furthermore, findings by Pandita and Kiran (2023) reinforce this, indicating that technology in learning successfully engages students behaviourally, emotionally, and cognitively in a positive manner during learning sessions. Technology provides greater opportunities for students to interact and engage with one another throughout the learning process. Alyoussef and Omer (2023) also emphasised that student satisfaction with active learning through technology is higher when they possess strong technological self-efficacy. High confidence in using technology leads to increased enjoyment, motivation, and engagement in TEAL.

Student perceptions toward the use of technology in learning have generally been very positive. However, there remains a gap in understanding student satisfaction from perspectives such as motivation and effort in actively engaging in TEAL. These factors are reflected in the level of student satisfaction regarding their use of technological tools or devices, their motivation, and their engagement within the TEAL implementation context (Shroff et al., 2023). This study aims to address this gap by exploring these aspects using a sample of participants with diverse course backgrounds within the same educational institution.

2.4 Challenges in the Use of Technology-Enabled Active Learning (TEAL)

Challenge refers to a situation that requires significant effort to complete a task effectively, testing an individual's capability and potentially hindering the learning process if left unaddressed (Hassan et al., 2021). Similarly, Jääskä and Aaltonen (2022) define a challenge as an activity that demands mental or physical effort to be completed successfully, thereby testing one's capabilities and emotions. Consistent with this definition, this study aims to explore the challenges faced by students in adapting to TEAL throughout their academic journey.

Previous studies have identified various challenges associated with the full adoption of TEAL in educational institutions. Juanatas and Revano (2023) emphasised the need for a deeper understanding of the difficulties surrounding the implementation of TEAL in higher education. Their research highlighted issues such as self-regulation, technological proficiency, student isolation, insufficient technological resources, technological complexity, and existing learning environments as major barriers to the effective implementation of TEAL.

Furthermore, limited access to devices and internet connectivity is another common problem (Kamble et al., 2021). In this study, challenges will be examined in terms of students' readiness to engage in TEAL, their self-efficacy in using technology, and the preparedness of their technological environment. These factors represent potential barriers that students may face when using technology in TEAL-based learning (Tang et al., 2021; Zalat et al., 2021; Shroff et al., 2023).

3. Methodology

This study employed a quantitative survey research design to examine students' perceptions of TEAL implementation in teaching and learning. The study focused on identifying the perceived effects, satisfaction, and challenges of TEAL, while also exploring gender-based differences. A structured questionnaire was developed and administered to collect data from undergraduate students enrolled in the Faculty of Technical and Vocational Education (FPTV), Universiti Tun Hussein Onn Malaysia (UTHM).

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3.1 Sample

The study sample comprised 287 undergraduate students from various programmes under the FPTV at UTHM. Respondents were selected through simple random sampling that consisted of both male (n=160) and female (n=127) students. The respondent selection criteria was that, the selected respondents must had experienced TEAL-based teaching and learning environments in their coursework.

3.2 Instrument

A structured questionnaire was developed as the primary data collection instrument. The questionnaire consisted of four main sections**:** (1) demographic information, (2) students' perceptions of the effects of TEAL, (3) satisfaction with TEAL-based learning, and (4) challenges faced in TEAL implementation. Items were adapted and modified from existing validated instruments (e.g., Vasimalairaja et al., 2020; Dori & Belcher, 2005) and adjusted to suit the local context and educational environment. All items in Sections B to D were measured using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. To ensure the reliability of the instrument, a pilot study was conducted. The results showed high internal consistency with Cronbach's alpha values of 0.879 (Effect), 0.903 (Satisfaction), and 0.935 (Challenges), indicating strong reliability.

3.3 Data Analysis

The collected data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 28.0. Descriptive statistics, such as mean and standard deviation, were used to summarise the findings to answer the research questions of this study regarding students' perceptions of the effects, satisfaction, and challenges of TEAL encountered in the learning process. For inferential analysis, the Mann-Whitney U test was employed to identify gender differences in perceptions related to the effects, satisfaction, and challenges of TEAL. This non-parametric test was selected due to the data not fulfilling the assumptions of normality, as assessed using the Kolmogorov-Smirnov test.

4. Results and Discussion

A total of 287 completed questionnaires were collected from undergraduate students at FPTV. The collected data were analyzed to address research questions related to students' perceptions of the effects, satisfaction, and challenges of implementing TEAL in teaching and learning. Data analysis involved the use of descriptive statistics (mean and standard deviation) and inferential statistics (Mann-Whitney U test) to test the research hypothesis. The following sections explain the findings in detail.

4.1 Students' Perception of the Effects, Satisfaction, and Challenges of TEAL in Teaching and Learning

Table 1 presents a summary of the descriptive analysis for each variables measuring students' perceptions of the effects, satisfaction, and challenges of TEAL in the learning process. The results show that the mean score of effects, satisfaction, and challenges are 4.45 (SD=0.24), 4.39 (SD=0.23), and 3.56 (SD=0.69) respectively. The analysis results indicate that the effects recorded a higher mean score compared to the satisfaction and challenge aspects in the use of TEAL among undergraduate students at the Faculty of Technical and Vocational Education (FPTV).

Table 1 *Analysis for students' perceptions of the effects, satisfaction, and challenge of TEAL in the learning process*

Variables	Mean (M)	Standard Deviation (SD)	Interpretation
Effects	4.45	0.24	High
Satisfaction	4.39	0.23	High
Challenges	3.56	0.69	Moderate

4.2 Gender Differences in Students' Perceptions of TEAL: Effects, Satisfaction, and Challenges

Table 2 summarises the inferential analysis for each variable measuring students' perceptions of the effects, satisfaction, and challenges of Technology-Enabled Active Learning (TEAL) in the learning process based on gender. The results of the Mann-Whitney U test revealed no significant difference between male and female students in terms of their perceptions of the effects of TEAL implementation ($U = 10031.500$, $p > 0.05$). Therefore, the null hypothesis is accepted. Next, for the satisfaction aspect, the Mann-Whitney U test value also indicated no

significant difference between genders regarding satisfaction with the use of TEAL (U = 9424.000, p > 0.05). Thus, the null hypothesis is also accepted for this aspect. Lastly, for the challenge aspect, the Mann-Whitney U test showed no significant difference between male and female students in terms of the challenges faced in using TEAL (U = 9732.500, p > 0.05). Hence, the null hypothesis is accepted for this aspect as well. Overall, the analysis results indicate that there are no significant differences in students' perceptions of the effects, satisfaction, and challenges related to the use of TEAL based on gender.

Table 2 *Analysis for students' perceptions of the effects, satisfaction, and challenge of TEAL in the learning process based on gender*

Inferential Test	Effects	Satisfaction	Challenges
Mann-Whitney U	10031.500	9424.000	9732.500
Asymp. Sig. (2-tailed)	0.852	0.282	0.540

4.3 Discussion

The discussion presented in this section is based on the four research objectives proposed, namely: to identify students' perceptions of the impact of using TEAL in teaching and learning, to identify students' perceptions of the use of TEAL in teaching and learning in terms of satisfaction, to identify the challenges faced by students in using TEAL in learning, and finally to identify differences in students' perceptions of the use of TEAL in terms of impact, satisfaction, and challenges based on gender.

4.3.1 Students' Perceptions of the TEAL Effects

Overall, the findings of the study indicate that the impact of using the Technology-Enabled Active Learning (TEAL) approach in teaching and learning at FPTV is perceived to be high by students. This shows that students responded positively to the effects of TEAL on their learning. These results are consistent with the findings of Shi et al. (2020), Tarmizi and Yahfizham (2024), and Salmi and Setiyanti (2023), who reported that the integration of technology in learning significantly enhances students' ability to access information, accelerates task completion, and strengthens conceptual understanding. For instance, Tarmizi and Yahfizham (2024) stated that technology enables university students to search for learning information more quickly and easily, thereby speeding up their learning process.

Furthermore, the findings are supported by Lohr, Sailer, Stadler, and Fischer (2021), who emphasized that digital learning characterized by interactivity and constructiveness promotes active learning and enhances students' learning experiences. This effect is attributed to the active learning elements within TEAL, which provide students with opportunities to directly engage in the learning process, collaborate and discuss, as well as optimally utilize technology for their learning. This, in turn, contributes to the development of a more meaningful learning environment and enriches students' learning experiences. This is supported by Justo et al. (2022), who found that technology-based active learning increases student engagement, motivation, and academic achievement.

In conclusion, the impact of TEAL implementation in teaching and learning at FPTV is positive and perceived as high among students. The strong impact of TEAL at FPTV, UTHM can be attributed to the faculty's technologically advanced learning environment, continuous support from lecturers, and a student-centered learning approach aligned with technical and vocational education practices. In addition, TEAL's emphasis on active involvement, constructive and interactive learning enables students to process information more quickly and deeply, thereby enhancing their conceptual mastery. The learning culture at FPTV, UTHM, which emphasizes the use of technology, also supports this positive effect. With a conducive learning ecosystem and a collaborative culture between students and lecturers, the implementation of TEAL has the potential to make a significant positive impact on students' learning experiences, thus explaining the high level of perceived impact.

4.3.2 Students' Perceptions Towards the Satisfaction of TEAL

Overall, the findings of the study indicate that students' satisfaction with the use of the TEAL approach in teaching and learning at FPTV, UTHM is high. This result demonstrates that students are generally satisfied and view TEAL as an effective learning approach. These findings are consistent with the studies by Odum et al. (2021) and Ab Rahman et al. (2022), which reported that technology-assisted active learning can enhance student satisfaction by making learning more meaningful and engaging. Additionally, the findings align with constructivist theory, which emphasizes the active and collaborative construction of knowledge within an interactive and conducive learning environment. Besides, students expressed satisfaction because the use of technology in TEAL encouraged them to actively participate in learning activities, which recorded the highest mean score. This result indicates that technology acts as a catalyst for active engagement, thereby enhancing student satisfaction. This is in line with the findings of Parrock (2022) and Seethamraju and Murthy (2023), who found that technology-based active

learning not only increases student engagement but also positively impacts the understanding of complex concepts. In addition, students also reported a high level of satisfaction because the TEAL approach improved their understanding of learning content. This finding suggests that students believe technology-assisted learning makes concepts easier to understand and relate to prior knowledge. This is supported by Hassan et al. (2020), who asserted that the use of technology in learning can clarify concepts and promote deeper learning.

In summary, the findings of this study indicate that students' perceptions of their satisfaction with learning through TEAL at FPTV, UTHM are positive and at a high level. The high level of satisfaction can be attributed to the learning environment at the faculty, which is equipped with advanced technological facilities and strong pedagogical support, alongside a learning culture that emphasizes active and student-centered learning. Moreover, the lecturers at FPTV, UTHM are committed to implementing innovative and interactive approaches, thereby creating a more meaningful and enjoyable learning atmosphere. These factors foster active engagement and strengthen conceptual understanding among students, thus explaining the high level of satisfaction reported. In other words, the impact of TEAL implementation at this faculty is not solely dependent on technology but is also supported by the lecturers' capabilities as facilitators and a learning culture that is conducive to 21st-century education.

4.3.3 The Challenges Faced by Students in Using TEAL in Learning

Overall, the findings of the study indicate that students experience a moderate level of challenges in using TEAL. This suggests that although TEAL offers many advantages in learning, there are technical and pedagogical barriers that need to be addressed to ensure its more effective implementation. These results are in line with the findings of Mustapha et al. (2021) and Mogavi et al. (2022), who reported that issues related to internet stability, learning software and platforms, as well as technological proficiency, are the main challenges in technology-based learning.

These findings can also be explained through Constructivist Theory, which emphasizes the role of social interaction and the use of learning tools as mediators in the construction of knowledge. In the context of digital learning, technical constraints and ineffective lecturer-student interactions can limit opportunities for active knowledge building. This explains why challenges such as internet stability, user-unfriendly platforms, and online interaction, recorded higher mean scores in the study. In other words, the intended impact of active learning can only be achieved if technical aspects and interactive support are prioritized in its implementation.

Hence, the moderate level of challenges can be attributed to the learning environment at FPTV, UTHM, which already provides technological support and basic training to students, thereby reducing the impact of critical technical and pedagogical barriers. Moreover, the continuous exposure to technology-based learning within the technical and vocational education programs has helped students become more proficient and confident in adapting to digital learning tools. However, factors such as internet stability and online interaction still require ongoing attention to ensure a smoother and more effective learning experience. In other words, the challenges of using TEAL at FPTV, UTHM are not at a critical level due to the existing learning ecosystem and institutional support, but more holistic improvements are still needed to minimize challenges and maximize the potential of technology-based active learning.

4.3.4 The Differences in Students' Perceptions of the use of TEAL in Terms of Effects, Satisfaction, and Challenges Based on Gender.

To address the fourth research question, the Mann-Whitney U test was used to determine whether there were significant differences between male and female students in their perceptions of the impact, satisfaction, and challenges of using the TEAL approach. The analysis results showed no significant differences based on gender for all three aspects; therefore, the null hypothesis was accepted. This means that gender does not influence students' perceptions of the implementation of TEAL in teaching and learning, and the TEAL approach can be universally accepted regardless of gender. These findings are consistent with a recent study by Mensah, Azila-Gbettor, Kugbonu, and Tahiru (2023), which found that students' perceptions of technology are more strongly influenced by their level of ICT self-efficacy rather than by gender. Additionally, a study by Saleh, Rosli, Abu Bakar, Md Ali, and Isa (2021) also reported that both male and female students showed comparable levels of satisfaction with technology-based learning during the pandemic, particularly in terms of interaction and the effectiveness of provided facilities during teaching and learning. Similarly, Mat, et al. (2021) found that gender did not show a significant difference in readiness and satisfaction levels with distance learning among students in higher education institutions. These findings further support the conclusion that technology-based approaches such as TEAL can provide an equitable learning experience across genders.

From a theoretical perspective, these findings support the principles of Constructivist Theory, which emphasizes that learning is constructed through experience, interaction, and social context, without prioritizing gender as a determining factor (Suryana, Aprina, & Harto, 2022). Other studies have also concluded that constructivist theory emphasizes students' active involvement in shaping their own understanding through the processes of gathering information, interpreting it, and connecting it to prior experiences (Istiadah, 2020). In this

context, constructivism highlights student-centered learning regardless of gender differences. This aligns with the findings of the current study, which show that the Technology-Enabled Active Learning (TEAL) approach also upholds this principle, where the effectiveness and student satisfaction with active learning are not influenced by gender.

Therefore, these results further reinforce the relevance of constructivist theory and active learning theory as the foundational basis for the TEAL approach, which offers equal opportunities for all students to engage actively and build understanding through interaction, technology, and collaborative experiences. The absence of significant gender-based differences demonstrates that TEAL implementation provides fair and inclusive learning opportunities for all students. This aligns with the principles of constructivist theory and active learning theory, which emphasize learning experiences through interaction and activity without discrimination based on gender or student background.

5. Conclusion

In conclusion, this study successfully examined and discussed students' perceptions of the use of the Technology-Enabled Active Learning (TEAL) approach in teaching and learning at the Faculty of Technical and Vocational Education (FPTV) in terms of impact, satisfaction, and challenges. The findings reveal that students hold positive perceptions of this approach, particularly in terms of its impact and their satisfaction. Students reported that the use of technology encouraged them to be more actively engaged in learning sessions and enhanced their understanding of lesson content. This indicates that the TEAL approach supports the principles of 21st-century learning, which emphasize active, collaborative, and technology-driven student engagement. However, the study also identified several challenges faced by students in the implementation of TEAL, including issues such as internet instability, difficulties in navigating various platforms, and a lack of meaningful online interaction. Although the average score for challenges was at a moderate level, certain items indicated a high level of difficulty, highlighting the need for support in terms of infrastructure, digital literacy, and lecturer guidance to reduce the burden on students.

6. Limitations of Research

There are several limitations in this research. Firstly, the respondents were limited to undergraduate students from Universiti Tun Hussein Onn Malaysia (UTHM), specifically within the Faculty of Technical and Vocational Education (FPTV). Therefore, the findings may not be generalisable to other educational contexts such as secondary schools, vocational colleges, polytechnics, or other higher education institutions, which may differ in terms of technological infrastructure, teaching practices, and student readiness.

Secondly, this study employed a quantitative survey design that relied solely on self-reported data. As such, the findings may be subject to response bias, including social desirability and individual interpretation of questionnaire items. The absence of qualitative data limits deeper insights into students' actual experiences and the underlying reasons behind their perceptions.

Thirdly, the study focused only on three variables, namely effects, satisfaction, and challenges, without considering other potentially influential factors such as academic performance, lecturers' competencies, or institutional support.

Finally, the cross-sectional nature of the study restricts the ability to examine changes in perceptions over time. Future research could adopt longitudinal or mixed method approaches to provide a more comprehensive understanding of TEAL implementation.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nur Ain Shuhada Ab Razak, Lai Chee Sern;* ***data collection:*** *Nur Ain Shuhada Ab Razak;* ***analysis and interpretation of results:*** *Nur Ain Shuhada Ab Razak, Lai Chee Sern;* ***draft manuscript preparation:*** *Nur Ain Shuhada Ab Razak, Lai Chee Sern, Md Najip Bin Talibin. All authors reviewed the results and approved the final version of the manuscript.*

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