

Enhancing TVET Education through the Learning Factory Approach: An Experiential Learning Perspective

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Abstract

This study investigates how the Learning Factory (LF) approach can enhance Technical and Vocational Education and Training (TVET) at Higher Education Institutions (HEIs), particularly in bridging the gap between theoretical knowledge and practical competence. A qualitative research approach was adopted, with data collected through structured questions and focus group interviews involving twenty-three undergraduate students who had completed a Lean Manufacturing course incorporating Learning Factory activities. The findings demonstrate that the Learning Factory provides an immersive and hands-on learning environment that strengthens students' conceptual understanding and facilitates the transfer of theoretical knowledge into practical application. Through engagement with simulated industrial processes, students were able to apply Lean Manufacturing principles to identify operational problems, analyse their causes, and develop improvement solutions. Participants also reported enhanced problem-solving abilities, teamwork, and the development of practical and industry-relevant competencies. The study contributes theoretically by demonstrating the applicability of Experiential Learning Theory (ELT) in simulation-based TVET education, particularly in facilitating the transformation of theoretical knowledge into practical competence. Practically, the study highlights the role of Learning Factory facilities in providing authentic learning experiences that prepare graduates for industrial environments. The findings have implications for industry, factory management, curriculum development, and teaching methodologies, particularly in designing experiential learning activities that enable HEI students to integrate theoretical knowledge with practical application while developing problem-solving, teamwork, and industry-relevant competencies aligned with contemporary workplace requirements.

Keywords: TVET, learning factory, qualitative, experiential, industry, education

1. INTRODUCTION

Although Technical and Vocational Education and Training (TVET) is crucial for creating highly qualified workers, it is frequently viewed by some people as a "second choice" option, which discourages students enrolment at higher learning institutions (HEIs) (Hashim, 2025). Inadequate collaboration between industry and HEIs often leads to curricula that are inadequately supported by contemporary industry demands. Such situation results in competency gaps among graduates and causing increase in hiring and training costs for firms (Buitek, 2025). Furthermore, acute shortage of trained academic staffs with sufficient industry

literacy and extensive industrial experience is one of the ongoing issues in Malaysian TVET education, substantially impacted on the quality of training provided in higher education institutions (Sulaiman et al., 2024). The creation of efficient and industry-relevant training settings is hampered by obsolete curriculum content and inadequate institutional finance, especially in some public Manufacturing TVET HEIs (Kamaruzaman, 2024, Al-Shouh & Al-Darawsheh, 2024). Lack of critical employability competencies, such as communication skills, critical thinking ability, teamwork capability, and practical workplace readiness, exacerbate these structural limitations and lower young graduates' competitiveness in the labor market (Ahmad et al., 2024). To solve this crucial issue, a comprehensive and well-considered strategy is required.

Learning Factory (LF) methodology addresses the gap that exists in the current HEIs curriculum by offering experiential, hands-on learning opportunities in manufacturing and production processes, thereby enabling the effective integration of theoretical knowledge with practical application. The significance of Learning Factory implementation in Higher Education Institutions (HEIs) has been widely documented in past literature. Previous studies have demonstrated its potential to facilitate the transfer of research outcomes to industry, while simultaneously enhancing learners' soft skills and overall professional competencies (Jing et al., 2023). Therefore, this study was developed based on the following research objectives:

- 1) To examine the role of the UMPSA Learning Factory facility in supporting experiential learning in TVET education
- 2) To explore students' perceptions of using the UMPSA Learning Factory facility to learn a TVET subject.

2. LITERATURE REVIEW

One of the reasons for unsuccessful knowledge transfer in Education is generally the lack of opportunities for students to apply theoretical knowledge in its practical contexts (Riedl, 2004, Al-Zaqeba et al., 2026). The acquisition of competence extends beyond the ability to understand and recall theoretical concepts; it also requires learners to demonstrate the ability to apply their knowledge, skills, and understanding to address practical problems and challenges (Qahman et al., 2026). Thus, knowledge alone does not necessarily constitute competence unless learners are able to translate what they have learned into appropriate actions within a specific context. Competency entails the ability to use knowledge to address practical difficulties and when the relationship between knowledge and the ability to use it is guaranteed (Klieme, 2007, Ayman, 2025).

This issue is mostly pertinent to Technical and Vocational Education and Training (TVET), where the development of competent graduates requires the integration of theoretical knowledge, practical skills, problem-solving abilities, and workplace-related competencies. Conventional classroom-based teaching may provide students with an understanding of concepts and principles, but it may lack opportunities for students to experience how these concepts operate under realistic working conditions (Al-Hassan, 2023, Elagha et al., 2025). Consequently, a gap may emerge between knowing what to do and knowing how to do it effectively.

The Learning Factory concept provides a potential approach for addressing this knowledge–practice gap. A Learning Factory is a practice-oriented learning environment that simulates or replicates relevant industrial processes, technologies, workflows, and working conditions within an educational setting (Quinn et al, 2025). It provides learners with opportunities to engage directly with production processes and to apply theoretical knowledge to realistic operational situations. Rather than learning manufacturing concepts solely through lectures,

students can experience production activities, identify operational problems, test improvement ideas, and observe the consequences of their decisions in a controlled learning environment.

The practical nature of the Learning Factory enables knowledge transfer to occur through a process of application, experience, reflection, and improvement (Maarof, 2025, Hazaimah, 2025). Through this process, theoretical knowledge is transformed into practical experience and subsequently reinforced through reflection and evaluation. This can be achieved as learning factory facility creates a learning environment in which students are required to connect theoretical concepts with practical decision-making. For instance, when students encounter problems during production activities in the learning factory, they must draw upon their theoretical knowledge to analyze the situation, determine possible causes, evaluate alternative solutions, and implement appropriate actions. Theoretical knowledge provides the foundation for action, while practical experience allows students to test and contextualize that knowledge. Reflection enables learners to evaluate their experiences and recognize the relationship between theoretical principles and practical outcomes. Through repeated application and experimentation, learners can progressively develop the ability to use knowledge appropriately in different situations. As a result, such learning process develops higher-order competencies such as critical thinking, problem-solving, decision-making, collaboration, and continuous improvement. Thus, Learning Factory facility plays a crucial function as a bridge between academic knowledge and the competencies required in industrial practice.

The Learning Factory concept should be viewed as more than just a physical facility which contains various manufacturing processes and equipment. It represents a pedagogical approach for facilitating knowledge transfer and competence development by creating a structured connection between classroom learning and actual industrial practice. By providing opportunities for students to apply, test, evaluate, and improve their knowledge in realistic production environments, the Learning Factory facility has the potential to reduce the gap between theoretical learning and practical application. This makes the Learning Factory particularly relevant to TVET education, where the ultimate objective is not simply for students to know, but to be able to effectively apply what they know in solving real workplace problems.

3. RESEARCH METHODOLOGY

This study employed a qualitative research approach to explore students' experience in learning a TVET subject in an LF work environment. Using techniques like focus groups and interviews, qualitative design employs a research framework to investigate intricate, subjective subjects like experiences, attitudes, "how" and "why" through detailed, non-numerical data, emphasizing rich context over general statistics (Laumann, 2020, Alzeyoudi & Ineizeh, 2025). To conduct in-depth, in-person interviews with participants, a focus group interview with numerous participants at once was carried out at the end of semester 2 session 2024/25. This enables them to learn as much as possible about the participants' experiences. Purposive sampling, a non-probabilistic sampling strategy commonly applied in qualitative research, was employed in this study. In purposive sampling, researchers deliberately choose participants, cases, or sites based on specific traits, knowledge, or goals. This study chose students who have attended the lean manufacturing subject using learning factory facility to be interviewed. The focus group interview session took place at the premises of the learning factory.

The study was conducted after the students have completed their course using the learning factory facility. This is done so that they can feel a complete cycle of studying a TVET subject using the learning factory facility. The TVET subject that was chosen was lean manufacturing, which teaches students about a production philosophy that maximizes customer value by

removing waste (non-value-added activities) and increasing manufacturing efficiency with the goal of achieving higher quality, lower costs, and shorter lead times through continuous improvement. In this course, the students were also taught various lean tools that are often used in industry to improve process efficiency (Almansour et al., 2026). A structured interview questions was the primary instrument used to gather qualitative data for this research. They were developed to answer the above research objective: What is the students' perception of using learning factory facility to learn a TVET subject? The interview questions were listed as below.

1. How does the Learning Factory experience differ from regular classroom learning in terms of your comprehension of Lean Manufacturing concepts?
2. How much has the Learning Factory helped your problem-solving or critical thinking abilities?
3. How has your Learning Factory experience prepared you to operate in a real-world manufacturing environment?
4. If a friend asked you what you gained from the Learning Factory experience, what would you tell them?

The learning factory facility at UMPSA, which was created in 2016 at the Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), simulates a small-scale supply chain manufacturing system by integrating multiple interconnected supply chain elements within a controlled educational environment. This facility replicates real-world manufacturing procedures by incorporating the following function: product design and development unit, additive manufacturing, fabrication workshop, a small end-to-end supply chain process, incoming and outgoing warehouse, and quality control.

The learning factory's implementation follows a systematic pedagogical process that combines theoretical underpinning with actual learning. During the first five weeks of the course, students attend a series of formal lectures to build a solid foundation in lean manufacturing ideas, tools, and practices. This phase focuses on conceptual understanding of issues such as lean waste, process design, workflow analysis, takt time computation, work measurement, and productivity improvement methods. After obtaining the essential theoretical background, students are exposed to curated manufacturing process videos that reinforce their understanding by visually demonstrating real-world industrial processes. This transitory phase connects classroom instruction and actual implementation.

Before commencing the hands-on activities, the instructor leads a guided tour of the learning factory. The tour allows students to examine and explore the facility's layout, equipment, machines, material flow, and overall production process. This orientation guarantees that students comprehend the physical system configuration and operational logic before beginning production operations. A USB fan is chosen as the prototype product for assembly in the learning factory. The product was deliberately chosen for its manageable complexity, many assembly activities, and suitability for showcasing lean manufacturing concepts such as line balancing and workflow optimization.

4. RESULT AND DISCUSSION

The respondents' demographic comprises of 23 third year undergraduate students. Four students (17.4%) are male whereas nineteen (82.6%) are female. These undergraduate students have studied a TVET course at Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) using the Learning Factory facility.

The data concerning the students' thoughts on using manufacturing facilities to learn a manufacturing TVET subject revealed three main themes which address the study's second

research objective. They are:

1. Theme 1: Ability to engage in experiential learning
2. Theme 2: Develop problem-solving skills
3. Theme 3: Establish industrial readiness feeling

The following paragraphs will explore in more detail about the student perceptions in using the learning factory methodology to learn a TVET subject.

Theme 1: Ability to engage in experiential learning

Experiential learning is a "learning by doing" pedagogical approach that engages learners through direct experience, active reflection, and application, rather than passive instruction. The following statement were given by the students:

"I can tell that in class we only learn theory, but at the Learning Factory we learn through real experience. It helps me increase my confidence in understanding concepts and work processes."

Participants 12

"Learning in the Learning Factory is more interesting because we can experience the real work environment ourselves. In the classroom, it's all theory but in the lab, we can see how the theory is applied in the production process."

Participant 13

From the interview data, we can derive that learning using learning factory facility has helped the students to apply theoretical concepts in a real-world context which made their level of understanding better. This was mentioned by participant 7 and participant 10.

"When we did the assembly ourselves, I understood the Lean process better."

Participant 7

"I learn faster when I actually do the process, not just listen to the lecture."

Participant 10

The setting up of a small-scale factory within the university premises that simulate a real factory underline the realistic environment as what can be found in a typical manufacturing industry. This notion was mentioned by participant 3 and participant 14 during the interview.

"The factory setup made us feel like we were in a real industry."

Participant 3

"It's just like working in an actual company where we must follow the SOPs and finish the task on time."

Participant 14

Students became more engaged, motivated, and dedicated to their learning process when they were actively involved in the Learning Factory activities. Instead of only listening to the lectures and acting as passive observers, the students contributed their thoughts to the decision-making, task management, and production problem-solving processes. Some of the participants reported feeling more "focused and excited" after completing the activities since they could immediately see the results of their actions. Participants 5 and participant 11 have attested to this:

"I was more focused and interested when we were doing the task ourselves."

Participant 5

"Working together to solve the problems made me feel more involved in learning."

Participant 11

Theme 2: Develop problem-solving skill

This theme centered on how students developed analytical and critical thinking through real industrial problems that occurred in the Learning Factory. Through the factory activity, the

students were able to exercise their problem-solving skill to recognize lean waste in the process, examine underlying root cause to problem in the process, and develop Lean-based process improvement. According to Rosário & Raimundo (2024), problem-based and experiential learning approaches in engineering and technical education could assist students in putting theoretical knowledge into practice in conjunction with cooperative principles and group decision-making. This was also mentioned by two participants during the interview.

“For me, Learning Factory helped a lot with my problem-solving skills. For example, during the assembly process, if we encounter difficulties, we had to find our own solutions. This trained me to think critically and creatively.”

Participant 1

“Learning Factory helped me learn from my mistakes. When a component could not be installed correctly, we had to find the cause and fix it. This helped me think more critically.”

Participant 5

During the activities in the Learning Factory, students gained the ability to think critically and methodically about problems pertaining to the production process. To develop suitable Lean-based solutions, they were able to identify the reasons for waste, delays, and inefficiencies in the process. Their capacity to apply theoretical ideas in a real-world setting improved their decision-making and problem-solving skills. The following were the comments given by the participants about their experience with critical thinking.

“We had to think carefully to find out which part caused the delay in the process.”

Participant 9

“The activity made me analyze why waste happened and how to reduce it.”

Participant 6

The students shared their opinions about making process improvement during the learning factory activities. They have the chance to try out knowledge they have gained during class lectures such as 5S, line balancing, and continuous improvement (Kaizen) to reduce waste, improve workflow, and enhance product quality. Some participants reported that after having the opportunity to use these tools, they had a more critical understanding of Lean concept. This principle was fundamental to Lean thinking, which believed that efficiency and continuous improvement were achieved by small, progressive changes based on experience, reflection, and the current circumstance. Their remarks were noted as follows:

“Our team used Lean tools like line balancing to make the process smoother.”

Participant 4

“We tried to use 5S to make the working area more organized and reduce time waste.”

Participant 12

Throughout the Learning Factory activities, students worked in teams, discussed problems, and brainstormed and implemented solutions collectively. The following comments were observed during the interview:

“We discussed as a team to find the best way to fix the problem.”

Participant 8

“Everyone shared ideas and worked together to make improvements.”

Participant 17

Theme 3: Establish industrial readiness among young graduates

Industrial Readiness relates to the extent to which university students possess the necessary skills, knowledge, attitudes, and behaviors to effectively transition from academia to the workplace and immediately contribute to professional, technical, or commercial objectives. This includes skills needed such as teamwork, safety consciousness, and professional communication through their direct involvement in actual production conditions. Fitrianto & Saif, (2024) argued that "experiential learning frameworks promoted student development of

collaboration and communication competence, those same skills needed in a complex learning experience such as in dynamic workplace settings." This notion was agreed by some participants as below

"Learning Factory gave me early exposure to the real work environment in the industry. I learned how to work in a team, stick to time, and understand work ethics, such as discipline and responsibility in each task."

Participant 1

"Through Learning Factory, I was exposed to the real factory environment — using machines, equipment, and following the actual work process. It made me more prepared and confident to work later."

Participant 4

"We learned to communicate with others and share responsibilities during the process."

Participant 5

"Working in a team taught me how to coordinate and support each other like in real factories."

Participant 15

At the learning factory facility, students also developed positive mindset regarding safety conscious. For instance, students used proper personal protective equipment (PPE), learned how to write efficient standard operating procedures (SOPs), and observed all safety precautions during class production assignments in the learning factory. Such attitude among the students help to develop a sense of responsibility, alertness, and self-control, which were indispensable for a productive and safe working environment.

"The instructor was strict about rules, so we learned to be disciplined and responsible."

Participant 2

"We had to follow the safety procedures and wear the proper PPE all the time."

Participant 11

The results of this study confirm the role of the Learning Factory (LF) at UMPSA as an effective pedagogical platform that incorporates theoretical teaching with experiential application in manufacturing education. This answers the Research Objective 1 (RO1). The LF environment enabled an active learning process to take place in which students were required not only to apply conceptual knowledge but also to reflect, adapt, and make decisions in dynamic production scenarios. This supports contemporary experiential and simulation-based learning paradigms that point up active engagement over passive knowledge acquisition.

The results reveal that the Learning Factory provided students with authentic exposure to production systems, thereby strengthening their understanding of Lean manufacturing principles, including lead time reduction, 5S implementation, line balancing, and Kaizen. Students reported that experiential engagement significantly enhanced conceptual clarity compared to the traditional lecture-based approaches. Similarly, their ability to identify bottlenecks, analyses workflow inefficiencies, and propose structured improvements reflect higher-order cognitive processing beyond basic knowledge recall. The integration of machinery operation, workflow coordination, and team-based problem-solving activities further contributed to the development of analytical thinking and practical decision-making skills. These findings reinforce the argument that immersive learning environments promote deeper conceptual internalization and more effective theory-to-practice transfer. This findings responds to the Research Objective 2 (RO2).

Theoretical Implications

This study contributes to the growing body of knowledge on experiential learning in manufacturing TVET subjects. It provides empirical evidence of how simulation-based

production environments facilitate meaningful learning experience. The findings extend current theoretical understanding of experiential learning by demonstrating that Learning Factory implementation not only enhances technical competence but also cultivates professional behaviors that are consistent with industrial practice, including teamwork, problem-solving, and continuous improvement orientation. Such competencies have the potency to produce graduates that are more industry ready. The results support the premise that structured experiential platforms serve as critical mechanisms for translating abstract Lean principles into operational competencies.

Practical Implications

From a practical perspective, the findings underscore the importance of strategic investment in Learning Factory infrastructure. Expanding workspace, increasing equipment availability, and extending operational hours have the tendency to enhance student engagement and allow for more comprehensive experiential cycles. Providing flexible access beyond scheduled laboratory sessions may allow students to engage in more iterative improvement activities, which are fundamental to Lean thinking. Furthermore, institutional commitment to resource allocation is therefore essential to maximize the pedagogical value of Learning Factory initiatives.

5. CONCLUSION

Overall, the study demonstrates that the Learning Factory represents a transformative pedagogical model capable of strengthening the integration of theory and practice in manufacturing teaching. By immersing students in realistic production simulations, the Learning Factory fosters deeper conceptual understanding, enhances critical thinking, and develops industry-aligned competencies. However, to realize its full potential, institutional commitment to adequate infrastructure, equipment, and scheduling flexibility is essential. These findings contribute to ongoing discourse on innovative teaching methodologies in manufacturing TVET and highlight the strategic importance of experiential platforms in preparing industry-ready graduates for the evolving demands of modern manufacturing systems. Despite its contributions, this study has drawbacks that must be acknowledged. Data were collected from a single institution, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), over one academic semester period. Consequently, the generalizability of the findings of this research work to other Learning Factory contexts remains limited. Future research should incorporate multi-institutional samples across Malaysia and other developing countries to enhance external validity. Longitudinal designs may also provide deeper insight into the sustained impact of Learning Factory participation in graduate employability and professional competence.

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