Industry-4.0 Based Teaching and Learning Technology: An Acceptance Investigation Among Mechanical Engineering Lecturers in Higher TVET Education Institution

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Abstract

The effect of industry 4.0 has instigated a wide range of technological development, especially in the manufacturing sector. This causes a systemic chain reaction in the education sector to prepare students for technological advancement in the industry. Higher TVET institutions play an essential role in providing highly skilled and work-ready workers to the industry due to their function in conducting work-related programs. To ensure the program is up-to-date with the current industrial revolution, the lecturers are needed to have a similar mindset and implement Industry 4.0 based courses in TVET institutions. Teaching and learning are the most crucial aspect of an educational institution. Therefore, the primary purpose of this research is to determine the level of acceptance regarding Industry 4.0 in the implementation of teaching and learning activities by utilizing the UTAUT Model. The data is collected from the lecturers of the mechanical engineering department and analyzed by utilizing the Statistical Package for Social Sciences (SPSS). Level of acceptance among mechanical engineering lecturers in a higher TVET education institution is revealed and shows a good acceptance level. The finding provides essential feedback and will inspire other researchers to explore further with a more significant sample.

Keywords: Industry 4.0, teaching and learning technology, engineering education, TVET

1. Introduction

The Covid-19 pandemic has created a global paradigm shift in major structures or frameworks, and the educational system is no exception. The Prime Minister of Malaysia proclaimed a national crisis on March 16, 2020, and announced a nationwide Restricted Movement Control Order (RMCO) and academic institutions' closures beginning March 18, 2020. The minister of education also indicated that various mediums, including online and television platforms, will be employed to guarantee that learning continues at home (Choi, et al., 2020). Since the fourth industrial revolution, the education system has been shifting toward virtual learning. Although it is distressing that the Covid-19 crisis has caused the education system to shift from traditional to virtual learning, it is critical to understand how instructors cope with the transition.

Industry 4.0 was first known as Industrie 4.0 when it was first introduced at a German industrial fair in 2011. Xu et. al., (2018) stated that the Industry 4.0 concept was formally proclaimed in 2013 as a German strategic initiative to assume a leading position in industries that are transforming the manufacturing industry. As seen in figure 1, industry 4.0 encompasses many innovations. Numerous new perspectives show that Industry 4.0 is the progression of the Fourth Industrial Revolution. Xu et. al., (2018) stated that with application of Information and Communication Technology (ICT) serves as the infrastructure basis of future innovation concept for industrial technologies and educational settings (Xu et. al., 2018). Figure 1 shows the linked direction, which shows the essential technologies that facilitate the transition from Industry 1.0 to Industry 4.0 (Baygin et al., 2017). The virtual learning environments and digital engineering education systems and methods might promote the utilization of this technology framework for industrial engineering and management utilization.

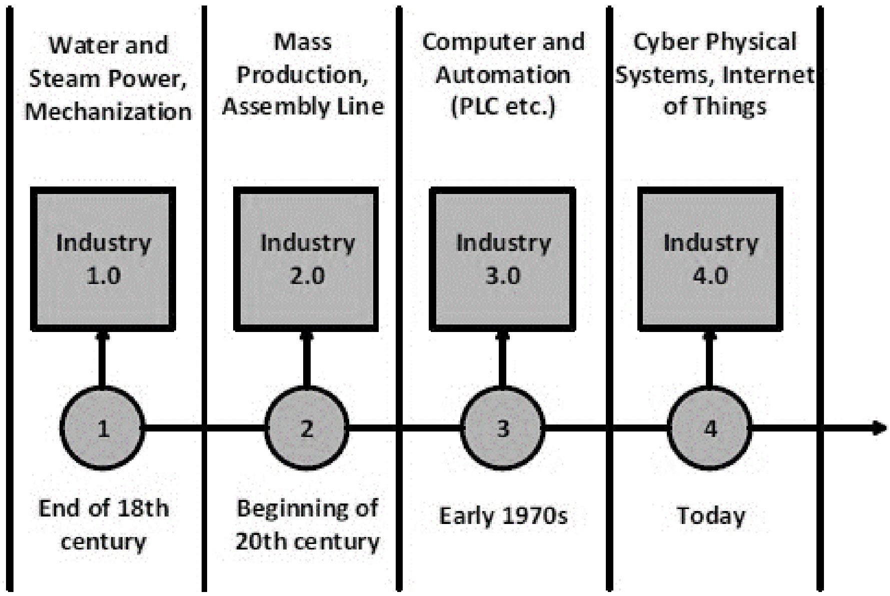

Fig. 1 The roadmap of industrial revolution (Baygin et. al., 2016)

2. Literature Review

Education 4.0 is a transformation of education institutions, and teaching and learning (T&L) methods depend on Industry 4.0 principles and digitalization. Developing skills and creating graduates' competencies for the current industry based on Industry 4.0 will be facilitated by the evolution of digital and virtual education accompanied by an Education 4.0 framework. Technology such as the simulation, augmented reality, virtual reality, cloud computing and data analytics play a key aspect in industrial and management education, facilitating enhanced continuing development of professional personnel Mourtzis et. al. (2018). Learning analytics has been shown to give insights into teaching techniques quickly altered (Sclater et. al., 2016).

In this 4.0 age, the learning environment for the students has shifted from the conventional teaching and learning model towards digital-based learning (Lase, 2019). Almost every academic element, including program development, lecturer knowledge and credentials, and the learning process, would be impacted by this technological adaption (Laily and Riadani, 2018). To simplify the process of adaption to the Industry 4.0 technology and digitization in the educational process, it is critical to emphasize teachers' competencies as shown in Figure 2.

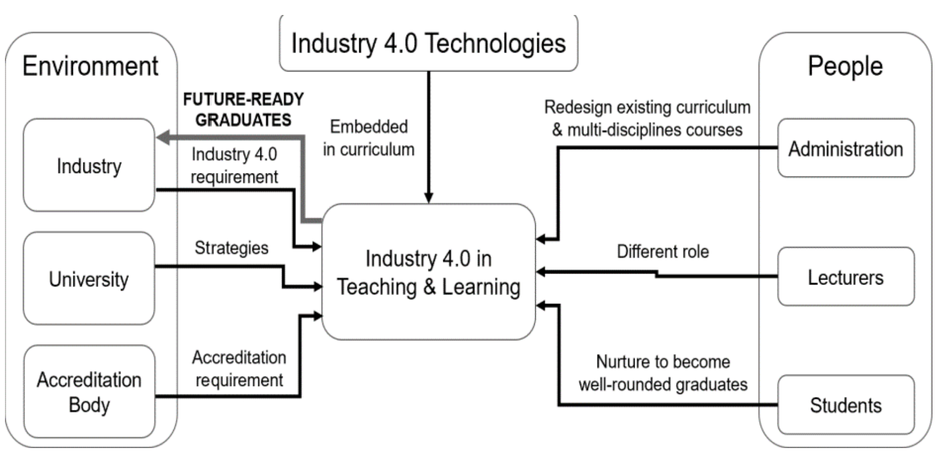

Fig. 2 Industry 4.0 Teaching and Learning (Mokhtar & Noordin, 2019)

The role of a lecturer in the higher education system is critical, as discussed by (Eloff et. al., 2021). Lecturers' responsibilities include preparing, advising, instructing, leading teaching, assessing, and reviewing students' progress. As the world changes and develops, it is necessary to improve the quality of human capital to compete worldwide, particularly in the industrial sector (Lase, 2019). Vocational education, commonly referred to as technical and vocational education training (TVET), focuses on education tailored to industry requirements (Affandi et. al., 2020 and Singh & Tolessa, 2019). As a result, TVET lecturers must grasp new capabilities in-depth to produce graduates who satisfy contemporary industry demands (Khirotdin et. al., 2019 and Marzuki et. al., 2022). Lecturers' competencies refer to the capacity to help students accomplish their learning objectives during the teaching and learning process (Ningsih, 2019). Lecturers, especially in the current technological progress, are responsible for transferring information, mindset, and spiritual growth to balance academic development and cognitive values (Lase, 2019). As a result, TVET lecturers must develop their adaptability to technological advancements and global issues.

For the current industrial situation, the higher TVET education institution aims are to produce well-trained and competent, industry-ready graduates (Tuselim, 2020). Because of the wide range of technical education, Amran et. al., (2020) believes that becoming a TVET lecturer is challenging. TVET lecturers should have a thorough understanding of their competencies to provide technical training that will enable future human capital to fulfill the demands of the digital era (Wagiran et. al., 2019). A good lecturer requires various professional capabilities and instructional talents to adapt to contemporary technologies (Flynn et. al., 2016). As a result, TVET lecturers' professional competencies must keep pace with technological advancements.

Learning technologies which arose with the development of electronic devices, have expanded the reach of electronic-based and virtual teaching and learning by enabling lecturers and students to teach and study wherever, any time, and on the go as stated by Irawan et. al., (2020). The delayed adoption rate by TVET educational institutions might be attributable to several factors. The expense of hardware and software solutions to enable Industry 4.0 based learning technology might be rather significant. The lecturer must also know by what means to use these technolgy tools to impart, interact with students, and assess their development. Additionally, the enormous expenses of accessing the technology through Internet connectivity may lead to poor adoption rates.

There are several technology adoptions investigations in the literature. As outlined by Fishbein & Ajzen (1975), the concept of perceived behavior is frequently used in the research to assess the level of technology acceptance. While other models have been applied in researches, the Unified Theory of Acceptance and Use of Technology (UTAUT) has gained much traction (Venkatesh et. al., 2003). However, one significant drawback of the research is that most technology adoption studies are conducted in Western cultures (Kaliisa et. al., 2019). As a result, evidence is scarce on whether the model links hold in other contexts. Because culture and country characteristics might modify measurements and connections across measures, applying the UTAUT model in non-Western settings may result in unsatisfactory results (Eid & Diener, 2009). As a result, before applying the model to the higher TVET education in Malaysia, it is necessary to re-assess its elements and their interactions.

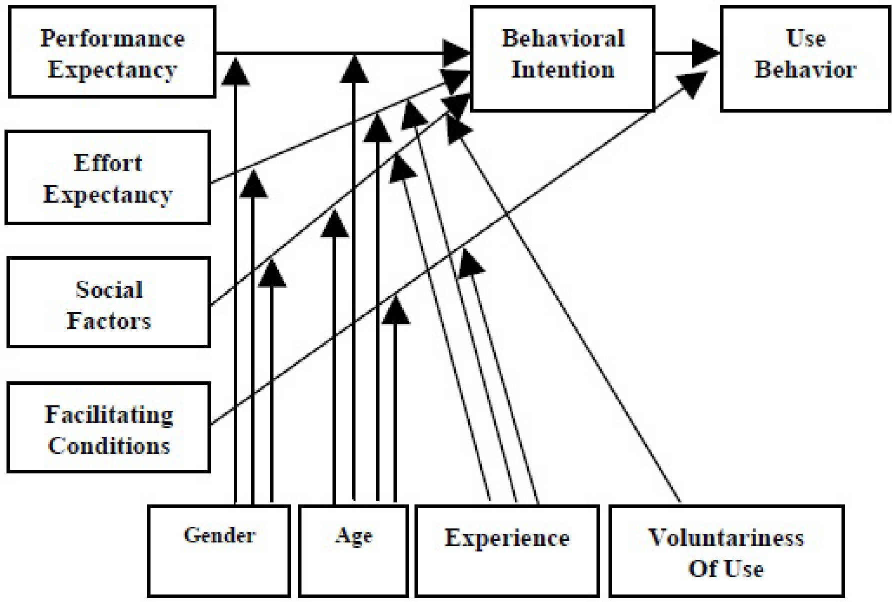

Fig. 3 The UTAUT Model (Venkatesh et. al., 2003)

In the UTAUT model, as shown in Figure 3, performance expectancy (PE), effort expectancy (EE), and social variables (SV) directly impact behavioral intention, which has direct significances on user behavior when shared with facilitating situations. Interactions of PE, EE, and SV with age and gender; interactions of experience with EE and social factors (SF); and interaction of voluntariness of usage and social factors (SF) on behavioral intention (BI) are similarly measured. As outlined by Venkatesh et. al. (2003), the interactions between age and facilitating factors, and experience facilitating conditions and impact use behaviors are also studied.

Though attitude is a crucial element of the Technology Acceptance Model (TAM) and Theory of Reasoned Action (TRA), it is not expressly incorporated in the UTAUT paradigm (Fishbein & Ajzen, 1975). The influence of attitude on behavior intention is apparent, and simply appears once PE and EE are removed from the model (Venkatesh et al., 2003). This indicates that attitudes about technology users do not supply enough specific information beyond what effectiveness prediction and effort expectation already provide.

3. Methodology

This study implemented a quantitative method that highlighted the descriptive approach to investigate the level of Industry 4.0 teaching technology acceptance among mechanical engineering lecturers. Sultan Azlan Shah Polytechnic is selected in this investigation because the institution is at the forefront of implementing Industry 4.0 based projects such as Smart Campus Initiative, Autonomous Vehicle Development, and Augmented Reality and Virtual Reality teaching module. Apart from that, Sultan Azlan Polytechnic is designated by the Ministry of Higher Education as a lead institution for Industry 4.0 implementation, especially for the TVET sector. The investigations utilize a cross-sectional approach where the input from the respondent is collected to fulfill the research objective. The unit of analysis is limited to mechanical engineering lecturers who serve full-time in the institution. Once the data from the questionnaire is collected, the data will be analyzed and further investigated to provide an insight into the acceptance level among mechanical engineering lecturers towards the Industry 4.0 based technology to be applied to teaching and learning activities. The study population comprised 75 lecturers in the Mechanical Engineering Department. By referring to Cohen et. al. (2007) sample size table, 63 lecturers is selected for the study with a confidence level of 95 percent.

The data for this study were collected by utilizing a web-based survey of the lecturers in the Mechanical Engineering Department of the Sultan Azlan Shah Polytechnic between November and December 2021. A portion on demographic data, a section on the use of different Industry 4.0-based technologies, and sections on UTAUT metrics were all included in the questionnaire. Before the survey's final launch, the instrument is verified with a group of 5 lecturers. The lecturers were chosen based on their convenience and readiness to take part. The instrument is distributed through email to all mechanical engineering department lecturers, and their participation is voluntary without any rewards.

The model in Figure 3 is used to assess the UTAUT variables and attitude. Each item is graded using a 5-point, clearly labeled with agree/disagree Likert scale. Many technologies adoption investigations utilize these items, although researchers must frequently alter the item key phrase to fit the situation (Kallaya et. al., 2009). Based on the feedback from the pilot implementation, the items were revised for the current research to improve respondents' understanding. To investigate the level of acceptance, a range of scores is developed to classify very low, to very high acceptance levels among the lecturers. Table 1 illustrated the mean score range level which is adapted from Kinay & Ardic (2017).

Table 1: Level of Mean Score Range

Level	***Interval***
Very low	1.00 – 1.80
Low	1.81 – 2.60
Moderate	2.61 – 3.40
High	3.41 – 4.20
Very high	4.21 – 5.00

4. Methodology

The total number of questionnaire returns is 32, compared to the sample of the lecturer selected for the study is 63. Therefore, the return rate of the sample is approximately 51%. The majority of the respondents in this investigation are male with 62.5% compared to females at 37.5%, with 65.6% aged between 31 years to 49 years old while the remaining is aged between 41 years to 50 years old. Moreover, the highest academic qualification among respondents is a master's degree with 59.4%, followed by a bachelor degree at 34.4%. Most of the respondents have been teaching in a TVET institution between 11 to 15 years with 50% and for about 43% of the respondents have accumulated between 6 to 10 years of teaching TVET programs. The remaining 43.8% is evenly distributed between academic staff with less than 5 years and 15 to 20 years of teaching experience. A descriptive analysis is carried out to answer the objective of the investigation. The summary of demographic information in relation to the study group is illustrated in Table 2.

Table 2: Demographic information of mechanical engineering lecturers participating in the research

Variable		***N: 32***	***%***
Gender	Male	*20*	*62.5*
	Female	*12*	*37.5*
Age	21 – 30 years	*0*	*0.0*
	31 – 40 years	*21*	*65.6*
	41 – 50 years	*11*	*34.4*
	51 years and above	*0*	*0.0*
Academic Qualification	PhD	*2*	*6.3*
	Masters	*19*	*59.4*
	Bachelor	*11*	*34.4*
Teaching Experience	Less than 5 years	*7*	*21.9*
	5 to 10 years	*4*	*12.5*
	11 to 15 years	*14*	*43.8*
	15 to 20 years	*7*	*21.9*

The item as explained earlier, is an adaptation from an investigation of technology acceptance which is previously conducted which also based on the UTAUT Model. The investigation variable is based on the UTAUT model is outlined in Table 3. The acceptance analysis is conducted by referring to the level of mean score range for each item in Table 1.

Table 3: The UTAUT Variable and Items

Variable	***Mean***	***S.D.***
Performance Expectancy	***3.96***	***.596***
PE1-Industry-4.0 Based Teaching and Learning Technology are useful in education in general	4.00	1.047
PE2-Using Industry-4.0 Based Teaching and Learning Technology enable students to accomplish tasks more quickly	4.06	.619
PE3-Industry-4.0 Based Teaching and Learning Technology would improve students' performance	3.84	.515
PE4-Industry-4.0 Based Teaching and Learning Technology would increase students' productivity.	*3.94*	*.619*
Effort Expectancy	***4.15***	***.728***
EE1-Industry-4.0 Based Teaching and Learning Technology are easy to use	4.03	1.031
EE2-Finding or using features in Industry-4.0 Based Teaching and Learning Technology	4.13	.793
EE3-Learning to operate Industry-4.0 Based Teaching and Learning Technology is easy	4.28	.581
Social Factors	***4.41***	***.609***
SF1-People who influence my behaviour think that I should use Industry-4.0 Based Teaching and Learning Technology	4.41	.875
SF2-People who are important to me think that I should use Industry-4.0 Based Teaching and Learning Technology for teaching	4.47	.761
SF3-The institution management are supportive of the use Industry-4.0 Based Teaching and Learning Technology	4.34	.483
Facilitating Conditions	***3.86***	***.317***
FC1-The institution management are supportive of the use of Industry-4.0 Based Learning Technology	3.66	.653
FC2-In general, the country in which my university campus is located has support (infra-structure, policies etc.) for Industry-4.0 Based Teaching and Learning Technology.	4.03	.309
FC3-I have the resources necessary to use Industry-4.0 Based Teaching and Learning Technology	3.63	.492
FC4-I have the knowledge necessary to use Industry-4.0 Based Teaching and Learning Technology	4.13	.660
FC5-Support from an individual or service is available when problems are encountered with Industry-4.0 Based Teaching and Learning Technology	3.91	.641
Attitude	*4.04*	*.164*
ATT1-Using Industry-4.0 Based Teaching and Learning Technology is a good idea	4.03	.177
ATT2-I would like to use Industry-4.0 Based Teaching and Learning Technology	3.97	.177
ATT3-I believe that working with Industry-4.0 Based Teaching and Learning Technology would be fun.	4.13	.336
Behavioural Intention	***4.49***	***.406***
BI1-I intend to use Industry-4.0 Based Teaching and Learning Technology in the next semester	4.38	.492
BI2-I predict I will use Industry-4.0 Based Teaching and Learning Technology in my courses in the next semester.	4.38	.492
BI3-I have a plan to use Industry-4.0 Based Teaching and Learning Technology in the near future.	4.72	.457
Average Mean	**4.15**	**.369**

The descriptive analysis demonstrated an overall average of high-level acceptance towards Industry 4.0 based teaching and learning technology (m=4.15, S.D.=.369) with the Social Factors and Behavioral Intention attained a very high level of acceptance. The acceptance level based on the primary variable is described in Table 4. Meanwhile, Performance Expectancy, Effort Expectancy, Facilitating Conditions and Attitude were achieved at one level lower than the both of Social Factors and Behavioral Intention. The lower acceptance level of Performance Expectancy is likely due to the lesser knowledge of utilizing Industry 4.0 based teaching and learning technology in mechanical engineering programs (PE3, m=3.84, S.D.=.515). Most of the industry in Malaysia has yet to fully utilized the Industry 4.0 technology, which might affect the implementation of Industry 4.0 based teaching and learning technology in the higher TVET institution. However, it is likely that the acceptance level will improve further in the future, where most mechanical and manufacturing industries fully adopt Industry 4.0 technology.

Table 4: Level of Mean Score, Standard Deviation and Level of Acceptance

Variable	*Mean*	*S.D.*	*Level*
Performance Expectancy (PE)	3.96	.596	High
Effort Expectancy (SE)	4.15	.728	High
Social Factors (SF)	4.41	.609	Very High
Facilitating Conditions (FC)	3.86	.317	High
Attitude (AT)	4.04	.164	High
Behavioural Intention (BI)	4.49	.406	Very High
Average Mean	**4.15**	**.369**	**High**

Facilitating Condition is a critical aspect to fully implementing Industry 4.0 based teaching and learning technology. From a mechanical engineering point of view, the Industry 4.0 technology can be adopted by utilizing simulation-based experiment methods such as Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), and Computational Design Methods (CAD) (Ralph et. al., 2020). Implementing virtual-simulation experiment requires enormous expenses, especially on the facilities to support the implementation, such as the software and hardware. The lower acceptance level for the Facilitating Condition variable is likely due to the lack of funding and the association to fully implement Industry 4.0 based teaching and learning technology. Besides that, the other contributing factor is the location of the TVET institution. Being located in the interior has primarily affected the institution's internet connectivity in which a fast internet connection is needed to link between components to extract data, especially for Internet of Things (IoT) application.

5. Conclusion

The outcome of each variable on the acceptance level of technology in implementing teaching and learning indicated that mechanical engineering lecturers in higher TVET institutions are willing to accept new technology to be utilized in the classroom. Although Performance Expectancy and Facilitating Condition recorded at a lower acceptance level, this is likely to change soon where the job sector needed Industry 4.0-specific skills to develop, operate, and maintain machinery. Facilitating Conditions is an important aspect in the implementation of new teaching and learning tools. The institution’s leadership and funding are the main contributing factor towards the acceptance of new technology in the institution. As stated by Marzuki & Ishak (2021) and Marzuki (2021), academic leaders need to have the effort and competency to TVET lecturers to embrace new method in teaching and learning.

The location of an academic institution could affect the connectivity or internet access especially if the institution is situated away from any suitable communication infrastructure. However, the recent development on the implementation of 5G communication technology under the federal government initiative might help alleviate the connectivity issue which plaguing education institutions in the rural area (Shayea et. al., (2021). Besides that, implementing 5G technology will narrow the internet connectivity between urban and rural settings whereby the facilities for 5G are less expensive than 4G infrastructure. Additionally, 5G connectivity will also boost the IoT implementation where the lecturers and students can access data seamlessly through electronic gadgets.

This research is a preliminary investigation on the acceptance level among higher TVET institution lecturers, and further analysis is needed in various public and private TVET providers in Malaysia to truly understand the technology acceptance level. The result from numerous settings such as urban and rural institutions may produce diverse insight towards the acceptance level. In addition to that, further analysis is needed to employ the technology acceptance model against the change management model within the Industry 4.0 perspective. This is because Industry 4.0 affects both the lower echelon in the organization and the institution's leadership. Therefore, there is still much more to explore in future research.

6. About the Author(s)

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