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Students' Critical Thinking Skills and Awareness of Industry 4.0: A Preliminary Study

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ABSTRACT

Students should be ready to satisfy the requirement of industry 4.0 in account of future jobs. Industry 4.0 requires its staff to be critical in data analysis and capable of working flexibly across a variety of company situations. Moreover, the World Economic Forum survey on future job highlighted the importance of critical thinking and problem-solving skills for future employment. However, currently, most of the employers stressed on the graduates' lack of critical thinking and problem-solving skills. Due to the fact that educational institution is a place to develop and enhance students' critical thinking and problem-solving skills, therefore this study explores the level of Kolej Universiti Poly-Tech MARA Kuala Lumpur (KUPTM Kuala Lumpur) students' critical thinking and problem-solving skills. This study also explores the students' awareness of Industry 4.0 in order to understand their perspective of the future workplace. A sample of 170 students from KUPTM Kuala Lumpur completed the survey. The findings from this research help us to identify the level of our students' critical thinking and problem-solving skills and their awareness about current industrial challenges. The findings also can be used for courses continuous improvement which to develop students with a higher capacity for reasoning and logical thinking. Students with a higher capacity to think critically will not only be appreciated as a workplace asset but will also have a bright future prospect.

Keywords: *Students' Critical Thinking, Industry 4.0, Globalization, Digitalization, Future Job.*

1. INTRODUCTION

National Industry 4.0 Policy Framework reported that Malaysia has a significant shortage of demanded talents, skills and knowledge for industry 4.0, especially in the areas of Internet of Things, robotics and Artificial Intelligent. Although programmers and technicians are highly required as they are directly connected in the sector, other positions are also essential to help company operations in the sector. In particular, Industry 4.0 will involve staff who can be critical thinkers, problem solvers, innovators, communicators and who can provide value-driven leadership, according to the (World Economic Forum, 2016).

The National Industry 4.0 Policy Framework reported that Malaysia manufacturing firms have a limited understanding of required future skills and expertise and limited in terms of readiness to embark on Industry 4.0 transformation. It is difficult to imagine how industry 4.0 is going to influence graduates' employability, but to generate competent graduates, universities need to provide skills that support the industry 4.0. For instance, in the era of advanced technology, accountants may not need to spend their time collecting and entering customer information or may no longer concentrate on preparing financial reports and tax returns, but they may be highly required to help organizations maximize value creation through smart financial policies or measure and report on the environmental footprint of companies. It is therefore essential for

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accounting graduates to be able to plan and believe critically as well as to be acquainted with techniques that are used in the field of accounting.

Corporate communication graduates are also important in Industry 4.0 because their expertise is needed due to the change of a manufacturer's production plant into a smart factory. Due to changing requirements and functions in the new trends, they must be equipped with knowledge and experience in developing of digitalization communication (Hauer, Harte & Kacemi, 2018). Basically, corporate communication officers are required to develop flexible communication strategies with internal and external stakeholders. Therefore, students in the program should be equipped with digitalization communication skills.

In industry 4.0, smart manufacturing's operations are digitalized connected and far more open to cyberattacks. Due to that reason, information security officers are in demand to protect data and to secure data sharing systems so that manufacturers and their supply networks are aware and prepared to counter any risks (Waslo *et al.,*, 2017). Therefore, students in the program related to cybersecurity should be prepared with appropriate knowledge and skills to fulfil the market demand.

As one of the Higher Educational Institutions in Malaysia, Kolej Universiti Poly-Tech MARA's (KUPTM) main objective is to ensure that graduates are adequately prepared for the local and global workforce. Therefore, KUPTM should realize its responsibility to prepare students to be a knowledgable worker for Industry 4.0. Basically, programs offered at KUPTM is in the area of business, accounting, communication and cybersecurity.

In order to explore KUPTM students' readiness for working environment in industry 4.0, this study intends to investigate the level of KUPTM student's critical thinking and problem-solving skills; to examine on the level of KUPTM programs' critical thinking; to explore the student's awareness of industry 4.0; to measure the student's expectation about the influence of industry 4.0 on workplace and their perception on the relevance of technologies connected industry 4.0. We also examine the correlation between programs' critical thinking with the students' critical thinking, their awareness on the industrial 4.0, future workplace and technology perception. The findings of this study can be used for courses continuous improvement to develop students with a higher capacity for reasoning and logical thinking required for industry 4.0's market demand.

2. LITERATURE REVIEW

2.1 Revolution of Industry and Human Capital Skills

Modern theory subdivides the Industrial Revolution into two phases: the first phase involves skill-saving technological change and minimal educational requirements and the second phase is where technological change increases the demand for human capital as skills become necessary for production (Becker, Hornung & Woessmann, 2011). Ample literature has highlighted the importance of human capital skills for economic development in the modern world. For example, according to Squicciarini and Voigtländer (2014), greater worker skills, entrepreneurial skills and scientific education are important to trigger a transition to sustained industrial growth.

The 1780s was the underlying year of Industry 1.0 where mass production was carried out by mechanical production powered by water (steam engines), therefore labour was intensively used to produce more goods and services (Agolla, 2018). Squicciarini and Voigtländer (2014) results revealed that besides greater worker skills were important in industry 1.0, the small entrepreneurial elite is also crucial in fostering growth via the innovation and diffusion of modern technology.

This is trailed continuously which is industry 2.0, where the power has entered the business at the start of the twentieth century. The used of electric motors to drive a group of machines benefit production in terms of power savings and greater control over machine speed. Then, the machine could be operated using individual electric motors (Greenwood, 1997). Mass production where the combination of single-purpose machines and unskilled labour to produce standards goods has been throughout this century (Sabel & Zeitlin, 1985).

The era of computers began in the 1950s where they were primarily used in academic and industrial research to perform calculations that were impractical or impossible to be done manually. In the 1960s, computers became file-keeping devices used by businesses to sort, store, process, and retrieve large volumes of data, thus saving on the labour involved in information-processing activities (Greenwood, 1997). Through Information Technology (IT), headquarters, design centres, plants, and purchasing and sales offices can be linked directly to one another, thus has reduced numbers of workers because productive output becomes possible with less unskilled labour (Greenwood, 1997). Industry 3.0, the third mechanical insurgency, begun when industry actualized the utilization of programmable electronic gadgets. The programmable gadgets increase the proficient and adaptability of generation in advanced robotization. This upheaval is still run today in current computerization framework. Companies can travel up or be advanced in IT by hiring skilled labour.

In the Industry 4.0, the smart factory uses computer integrated manufacturing system that integrates production technology, communication and computer equipment so that the company able to produce customized products, with high quality, affordable price and on-time delivery (Hozdiü, 2015). Therefore, the factory will develop cyber-physical systems for managing interconnected systems between its physical assets and computational abilities (Lee, Bagheri & Kao, 2015). In order to operate in the advanced technology era, the business will require a higher capability of workers. As future human capital, university students need to equip themselves with knowledge and critical thinking and problem-solving skills.

Table 1 demonstrates the span and developments on how the industry has advanced from Industry 1.0 up to the most recent Industry 4.0.

Table 1 Industry 1.0 to 4.0 comparison on the technology used

Industrial Revolution	Duration	Technology
Industry 1.0	Late 18th century	Mechanical production using water and steam power
Industry 2.0	Beginning of 20th century	Mass production using electricity
Industry 3.0	Beginning of the 1970s	Adoption of computers and Digital automation
Industry 4.0	Present	Smart and autonomous systems fuel by data and machine learning. Cyber-physical system

2.2 Critical Thinking and Problem-Solving Skills for Industry 4.0

Most employers expect automation and the adjustment to digitization will benefits employment as they will need new skills (ManpowerGroup 2016). Besides specialist roles in technologies such as big data specialist and Information Security Analyst, roles that are expected to grow that involve in human dealings by 2022 are such as customer service workers, sales and marketing professionals, training and development, people and culture, organizational development specialist and innovation managers (World_Economic_Forum 2018). By 2022, employers will require their employees to upskilling their soft skills such as creativity, originality and initiative, critical thinking, persuasion and negotiation will increase the employees value, as well as attention to detail, resilience, flexibility and complex problem-solving skills (World_Economic_Forum 2018).

2.3 Program's Critical Thinking and Students' Critical Thinking

Previous studies have discovered that formal classroom and non-classroom experience have a significant impact on critical thinking of learners (Terenzini *et al.,* 1995). Structured program or curriculums were also found to significantly influence students' critical thinking and problem-solving skills (McMillan 1987; Tsui 1999). Curriculum design that able to enhance student's critical thinking is a curriculum that able to encourage students' creativity and interest, which provides a collaborative learning experience, added with clear course materials and assessment that able to develop students' research and writing skills (Whiley *et al.,* 2017).

The Minister of Higher Education encourages cooperation between the industrial sector and educational institutions in several programs such as CEO @ Faculty Program and 2u2i Program due to the fact that program or curriculum can help improve the critical thinking of learners for industry 4.0. For example, CEO @ Faculty that have been started since 2015, is a program where CEOs share their knowledge and experiences with students and the university community. The CEOs will provide mentorship and guide universities in developing curriculum to ensure relevance to the industry. Whereas, the 2u2i program will expose students with industrial training throughout their study – two years of study and 2 years of industrial training. Therefore, students will be able to learn and experience in real industrial life.

3. METHODOLOGY

This preliminary study was conducted to examine the level of KUPTM students' critical thinking and problem-solving skills, programs' critical thinking, students' awareness of Industry 4.0, students' expectation about the influence of industry 4.0 on workplace and also students' perception on the relevance of technologies connected to industry 4.0. This study also examines the correlation between the programs' critical thinking with the students' critical thinking and their awareness of industrial 4.0. Table 2 summarized the research questions and research objectives.

Table 2 Research questions and research objectives

Research Questions	Research Objectives
1. **What are the level of our students' critical thinking and problem-solving skill?**	To explore the level of the students' critical thinking and problem-solving skill.
2. **What is the level of our programs' critical thinking?**	To study on the level of our programs' critical thinking.
3. **What is the level of our students' knowledge of Industry 4.0?** **- their awareness** **- future job in industry 4.0** **- technologies use in industry 4.0**	To examine the students' awareness of Industry 4.0. To study the students' expectation about the influence of industry 4.0 on the workplace. To investigate the students' perception on the relevance of technologies connected to industry 4.0.
4. **Is there any relationship between our programs' critical thinking with the students' critical thinking and their awareness on the industrial 4.0?**	To examine any correlation between our programs' critical thinking with the students' critical thinking and their awareness on the industrial 4.0.

By using convenient sampling method, a total of 300 questionnaires have been distributed to students in the program of Bachelor of Accountancy, Bachelor of communication (Hons) in Corporate Communication, Bachelor (Hons) in Information Security, and Diploma in Accounting and Finance. These three programs were chosen due to the importance of these field of study to supply graduates in the area of business, accounting and information technology for Industry 4.0. Total of students for these degrees and diploma program is 812 students. Students completed the questionnaire indicating 20.9% response rate.

A set of questions were developed for variables as follows: students' critical thinking and problem-solving skills, program's critical thinking, students' awareness of industry 4.0, the expectation on future job and expectation on future technology. This study adopts eleven statements of critical thinking and problem-solving skills from Rodzalan and Saat (2015). The eighty statements of program's critical thinking instruments were adopted from Murguia *et al.,* (2011) and the instruments of the student's awareness on Industry 4.0, the expectation on a future job as well as the expectation on future technology were adopted from Souza De Oliveira & Sommer (2017).

4. DATA ANALYSIS

Table 3 reports the distribution of respondents' demographic related to gender, age, and academic disciplines. From a total of 170 students who involved in the survey, 98 were female students (57.6%) while 72 students were male students (42.4%). Students between the age of 18 to 25 (97.7%) dominate the sample. The distribution of respondents in regard to program-level indicates that diploma respondents accounted for 50.6% while 49.4% were degree level respondents.

Table 3 Demographic of respondents

	Students' Demographic	Number	Percentage
Gender			
	Male	72	42.4
	Female	98	57.6
Age			
	18-19	63	37.1
	20-25	103	60.6
	26-30	3	1.8
	>30	1	6
Program			
	Degree in accounting	54	31.8
	Diploma in accounting	69	40.6
	Degree in corporate communication	38	22.4
	Degree in information security	9	5.3
Semester Level			
	SEM 1 -2	66	38.8
	SEM 3-4	21	12.4
	SEM 5-6	56	32.9
	> SEM 6	22	12.9
	Missing	5	2.9

Table 4 shows the mean, standard deviation (S.D) and Cronbach's alpha (α) value for variables used in this study. The Cronbach's alpha for the student's critical thinking and problem-solving, program's critical thinking, student's expectation on future job and student's expectation on future technology is 0.83, 0.97, 0.79 and 0.82 respectively. All values exceed the 0.7 criteria, indicating that the measurement has good reliability. While students' awareness of industry 4.0 was only measured by one question.

Table 4 Reliability results of variables understudy

	Item	Mean	SD	Cronbach alpha α
1	Student's critical thinking	3.85	0.55	0.83
2	Program's critical thinking	4.02	0.44	0.97
3	Expectation on future job	3.92	0.44	0.79
4	Expectation on future technology	3.88	0.62	0.82

Table 5 shows the measurement of students' perception of their critical thinking and problem-solving skills. The measurement scale was applied using a 5-point Likert scale, where 1 represented strongly disagree and 5, strongly agree. Overall, the mean score for each statement reports above 3.00 indicating that students perceived that their critical thinking and problem-solving skill is moderately high.

Table 5 Student's critical thinking and problem-solving skills

	Item	Mean	SD
1	In seeking satisfaction through my work, I tend to have a creative approach to solve problem-solving.	3.95	0.72
2	In carrying out my day-to-day work, I tend to see a pattern in solving problems where others would see items as unconnected.	3.77	0.75
3	When suddenly asked to consider a new project, I am able to take an independent and innovative look at most situations.	3.71	0.74
4	I can see how ideas and techniques can be used in perceiving new relationships.	3.99	0.71
5	I analyse other people's ideas objectively, by evaluating both advantages and disadvantages.	4.08	0.66
6	In seeking satisfaction through my work, I like to make critical discrimination between alternatives.	3.71	0.82
7	When trying to solve a complex problem, I like to weigh up and evaluate a range of suggestions thoroughly before choosing.	3.92	0.76
8	In carrying out my day-to-day, I can usually find the argument to deny unsound propositions (ie. Propositions that contain invalid facts)	3.8	0.71
9	If I am suddenly given a difficult task with limited time and unfamiliar people, my feelings seldom interfere with my judgement.	3.66	0.84
10	When suddenly asked to consider a new project, I approach the problem in a carefully analytical way.	3.82	0.74
11	I take a considerable amount of time to make a judgment but most often, the judgment made is accurate.	3.69	0.76

Table 6 shows the measurement of students' awareness of Industry 4.0. Most of the students aware of Industry 4.0 however, they do not understand its application and have not prepared for it (22.9%). This result is expected due to the strong dissemination of the topic "Industry 4.0" in the media. However, further studies should be developed for confirming such reasons. Therefore, students were asked whether the students familiar with the following terminology or the technologies in Industry 4.0 (refer Table 7).

Table 6 In which degree do you know the topic "Industry 4.0"?

	Item	Frequency	%
1	I did not know the term Industry 4.0 before this survey	0	0
2	I have already heard about Industry 4.0, but I do not understand its applications	80	47.1
3	I know the topic Industry 4.0 in general and have an idea of possible applications	50	29.4
4	I know the topic, but I have not had any kind of related preparation during my academic studies	39	22.9
5	I know the topic and I have already worked with it	1	0.6
	Total	170	100

Table 7 Do you know these technologies or processes related to digitalization/ industry 4.0?

Item	YES %
Big-Data-Driven Quality control	51.8
Robot-assisted production	55.9
Self-driving logistics vehicles	51.2
Product line simulation	58.2
Smart supply network	70
Predictive maintenance	46.5
Machines as a service	70.6
Self-organizing production	68.2
Additive manufacturing of the complex part	47.6
Augmented work, maintenance and service	57.1

According to the results presented in Table 7, it is confirmed that the students may have heard about future technologies in Industry 4.0. Table 8 shows the measurement of students' expectation about the influence of Industry 4.0 workplace. The measurement scale was applied using a 5-point Likert scale, where 1 represented strongly disagree and 5, strongly agree. Overall, the mean score for each statement reports above 3.00 indicating that most students moderately agreed with the changes of future job in industry 4.0. These findings suggest that they have a lack of understanding about their future job in industry 4.0. In other words, they are unsure about what their future workplace would be.

Table 8 Student's expectation about the influence of Industry 4.0 workplace

	Item	Mean	S.D
1	Academic jobs will be automated and substituted by machines	3.55	0.9
2	Business jobs will be automated	3.64	0.76
3	Research and development will be more important	4.05	0.77
4	The cooperation between universities and companies will be intensified	4.01	0.73
5	There will be different jobs and career in comparison to current jobs	4.05	0.73
6	There will be new products on the market and companies will require new knowledge for product development	4.06	0.75
7	New technologies and processes will drastically change the production line	3.99	0.68
8	The cooperation between teams will be more important	4.07	0.75
9	The institutional borders between companies will become less strict (e.g more interinstitutional projects)	3.85	0.75
10	The cooperation between teams will be more relevant	3.96	0.7

Table 9 shows the students' expectation of future technologies uses in Industry 4.0. The measurement scale was applied using a 5-point Likert scale, where 1 represented strongly disagree and 5, strongly agree. The findings show that most students moderately agreed that these technologies are connected to industry 4.0. These findings suggest that the students were not familiar with the technologies.

Table 9 Students' expectation of future technologies

	Item	Mean	S.D
1	Web 2.0 / mobile gadgets	3.89	0.73
2	Cyber-physical systems/ internet of things (connectivity between machines and processes)	3.89	0.81
3	Additive manufacturing (Laser-sintering, 3D-Druck etc)	3.84	0.78
4	Wearables, such as "Intelligent gloves" or virtual reality gadgets.	3.89	0.76

A summary of the results of correlations between the variables studies is presented in Table 10. The results revealed that the program's critical thinking was significantly and positively correlated to student's critical thinking and the students' expectation on a future job. This indicates that high scores on the program's critical thinking were associated with high scores on measures of student's critical thinking and student's expectation on a future job. However, the program's critical thinking was not significantly correlated with students' awareness in Industry 4.0 and their expectation of future technology. The results in Table 10 also revealed that the student's critical thinking was significantly and positively correlated to expectation on future job and expectation on future technology. This indicated that high scores on the student's critical thinking were associated with high scores on measures of student's expectation on future job and future technologies, but not their awareness on industry 4.0.

Table 10 Correlations between variables

	Item	1	2	3	4	5
1	Knowledge on industry 4.0	1				
2	Program's critical thinking	0.025	1			
3	Student's critical thinking and problem-solving	-0.017	.473**	1		
4	Expectation on future job	-0.08	.469**	.352**	1	
5	Expectation on future technology	-0.105	0.132	.190*	.404**	1

5. DISCUSSION

This research is expected to provide a preliminary study on the level of KUPTM students' critical thinking and problem-solving skills, programs' critical thinking, the students' awareness of Industry 4.0, the students' expectation on the workplace and the technology used in industry 4.0. The reliability analysis and descriptive analysis had been done by getting feedback through a structured questionnaire from students in accounting, corporate communication and information security programs. The reliability analysis was determined by the Cronbach Alpha value. The Cronbach Alpha value obtained was above the acceptable level of 0.7. Hence, it is satisfactory for reliability analysis. Moreover, the descriptive analysis through the mean score and standard deviation revealed a relatively high agreement and acceptance towards both measurement items in the variables.

According to the findings, most of the students agreed that their programs have developed critical thinking skills, but they perceived that their level of critical thinking and problem-solving skills are moderately high (Table 5). However, the program's critical thinking was significantly and positively correlated to student's critical thinking. Even though most of the students were found not ready for Industry 4.0 (Table 6) but most of them knew about the future technologies terminologies (Table 7). Besides that, students' expectation on the changes of their future workplace was quite high (Table 8), but they were not familiar with the future technologies that will be used in the Industry 4.0 (Table 9). These findings were inlined with previous findings that even the Brazilian students were not much aware of Industry 4.0 (Souza De Oliveira & Sommer 2017).

The preliminary findings in Table 10 show the significant and positive correlation between the program's critical thinking with students' critical thinking and the students' expectation of a future job. These findings suggest that KUPTM's programs have their strength in developing their students' critical thinking and probably it had influenced their students' perception of their future jobs. However, the programs did not have any significant correlation with students' awareness of Industry 4.0. One of the reasons might be because the programs have not prepared the students academically towards Industry 4.0 (Table 6). The findings also revealed that the students' critical thinking was significantly and positively correlated to their expectation on future job and their expectation on future technology.

The findings suggest that this institution should enhance students' awareness of industry 4.0 through programs development, apply technology in teaching and learning process in order to encourage students' innovation and to learn individually. Besides that, new interdisciplinary programs need to be developed in order to cater the future needs. Nevertheless, KUPTM should have close collaboration with industry and stakeholders in order to understand more on industry 4.0.

The limitation of this research is the participation of only several programs and few students as respondents, therefore care must be taken when reaching a general conclusion for all the programs of KUPTM and the students. Besides that, more in-depth studies need to be performed due to the absence of empirical research of industrial 4.0 in the field of social science.

6. CONCLUSION

With some preliminary insight into addressing industry 4.0 awareness of students and the relationship with critical thinking of the program through this paper, it is hoped that KUPTM will have at least some indications on the level of their program ability to develop critical thinking and awareness about industry 4.0 among students. This article, therefore, defines and offers some promising opportunities for future studies and offers some interesting preliminary empirical evidence of the connection between critical thinking of learners and their expectations of future workplace and technology.

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