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Awareness and Barriers of Industry 4.0 and Education 4.0 between Construction Players and Academicians in Malaysia

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Abstract: The digitisation of technologies heavily influences the construction industry with requirements for a new set of knowledge and a skilled workforce. Relatively, the adoption of Industry 4.0 in the work environment changes the current pedagogy at educational institutions through Education 4.0. The importance of adopting and adapting Industry 4.0 with Education 4.0 in construction engineering pedagogy is to create awareness of innovative technologies and to equip graduates with futuristic skills and knowledge. Even though the adoption of Industry 4.0 and Education 4.0 has taken place in the field of construction, limited studies were found on this subject matter, particularly in comparing the awareness between the industry and academia. Hence, this study examines the awareness and barriers of Industry 4.0 and Education 4.0 adoption between the industry players and academicians from the construction engineering perspective. A structured questionnaire survey was developed and distributed within public construction projects and public universities across Peninsular Malaysia. Data for this study were collected through face-to-face meetings and online survey distribution. Findings from the two different categories of respondents with different age range and academic qualifications provide similar, as well as dissimilar outcomes on the awareness and knowledge in accordance with their nature of work. Nonetheless, both distinct respondents have found financial constraint to be the most critical barrier for Industry 4.0 and Education 4.0 adoption. This study provides the revelation on the current state of awareness, knowledge and barriers among the players (industry and academic) in construction engineering and these insights could be further delineated for future action plans in aim to increase the adoption of Industry 4.0 within the field.

Keywords: Industry 4.0, education 4.0, construction engineering, industry practitioners, academicians

1. Introduction

The transformation in the construction industry sector impacts the Malaysian economy as a catalyst, as well as the ability to improve the way of living by accommodating customers' requirements and needs. Industry 4.0 adoption in the construction industry transforms project lifecycle from Information Communication Technology (ICT) into digitisation technology. The concept of Industry 4.0 in construction embraces multiple interdisciplinary technologies to enable digitisation, automation and integration across the entire construction value chain (Oesterreich & Teuteberg, 2016). The adoption of new technology is expected to prevent the recurrence of previous problems and challenges such as delay, cost overrun, and defects in the construction industry.

Current technological advancement requires different sets of knowledge, skills and techniques among the players to expedite the construction process with better quality development within the project cost constraint. Therefore, the education institution plays an essential role in preparing the future graduates with Industry 4.0 comprehension. New

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educational pedagogy and training development should comprise Industry 4.0 and Education 4.0 ideas to appraise and amend the current program structure (Seres, Pavlicevic & Tumbas, 2018). Pedagogical changes at educational institutions are expected to increase students' probability of being employed and further practice the Industry 4.0 and Education 4.0 concepts in the construction industry.

In general, the perception between the industry players and academicians on Industry 4.0 and Education 4.0 adoptions are critical to sustaining the construction industry lifecycle successfully. However, previous studies have shown a static change in the construction industry development due to the lack of knowledge and experience in Industry 4.0 (Baena *et al.*, 2017). The motivation of this study was triggered by the low understanding and adoption level of new technological innovation in construction engineering (Xue *et al.*, 2014). Based on previous studies, several Industry 4.0 technologies used in construction are still at the beginning phase or known as the prototype, resulting in slow adoption of digitisation (Oesterreich & Teuteberg, 2016). Besides, most researchers have focused on the benefits of Industry 4.0 and Education 4.0 but only a few have highlighted the barriers to successfully adopting and adapting the new technological transformations.

The adoption and adaptation of Industry 4.0 and Education 4.0 in the construction industry are to ride along the waves of technology changes and bridge the gap between the industry and the education sector. Hence, this study aims to examine the awareness of Industry 4.0 and Education 4.0 adoptions from the construction engineering context between construction industry players and academicians. In order to achieve the aim of this study, two objectives are determined as follows: 1) to identify the current knowledge of Industry 4.0 and Education 4.0 among industry players and academicians from the construction engineering perspective, and 2) to examine the challenges in adopting Industry 4.0 and Education 4.0 in the construction engineering sector. The fundamental questions asked in this study are:

- RQ1: Do industry players and academicians aware of Industry 4.0 and Education 4.0 in the construction industry?
- RQ2: Which Industry 4.0 and Education 4.0 concepts and tools are familiar to the industry players and academicians?
- RQ3: What are the challenges to adopt Industry 4.0 and Education 4.0 in the construction industry?

1.1 Industry 4.0 in Construction

The key technologies applied in the construction industry are based on the nine pillars of Industry 4.0 introduced in the manufacturing industry. The nine pillars consist of Big Data and Analytics, Autonomous Robots, Simulation, Horizontal and Vertical Integration, Internet of Things, Cyber Security and Cyber-Physical System, Cloud Computing, Additive Manufacturing and Augmented Reality (Rüßmann *et al.*, 2015). In addition, Artificial Intelligence and Advanced Materials were also considered one of the enabling technologies as part of the Industry 4.0 components (Ministry of International Trade and Industry, 2018). According to the World Economic Forum, there are three planning groups of digitisation technologies from the construction perspective, together with the Cybersecurity components, namely user interfaces and application, software platform and control and digital or physical integration layer (Gerbert, 2016). Additionally, previous researchers have also categorised industry components in construction into three main clusters, which are smart factory, simulation and modelling, and digitisation and virtualisation (Oesterreich & Teuteberg, 2016).

The perception towards Industry 4.0 differs between countries and disciplines due to diverse impacts concerning each realm. Few prior studies have been conducted to measure the level of awareness of Industry 4.0 adoptions across the globe. A study conducted in the Dominican Republic construction industry found that organisations need to adopt by changing the current culture (Oesterreich & Teuteberg, 2016). Major firms in Germany and the USA have positively anticipated the Industry 4.0 adoption as an opportunity, while the Japanese do not have the same point of view (Ślusarczyk, 2018). In addition, studies found that the level of awareness among construction professionals was extremely limited due to the lack of knowledge on Industry 4.0 subjects, along with minimal investments placed on research and development in technological innovations (Osunsanmi, Aigbavboa & Oke, 2018).

1.2 Education 4.0 in Construction Engineering Education

The impact of the Industrial Revolution has transformed the concepts of education by focusing more on the development of people by offering grounding learning including skills to society (Saxena et al., 2017). Education 4.0's epitome of learning pedagogy is to generate digitisation future-ready graduates who are independent, flexible in choosing their own learning path with better communications and interactions with each other (Department of Higher Education Malaysia, 2018). Education transformations are vital in preparing future graduates for the actual working environment, as well as to fulfilling upcoming job requirements and eradicating current construction challenges. The vision of Industry 4.0 adoption at educational institutions is an indicator towards preparing future graduates in attaining higher-level knowledge, along with the concepts and applications (Coşkun, Gençay & Kayıkcı, 2016). As an example, the adaption of the Industry 4.0 concept in the educational pedagogy is a computer-based simulation, such as the

Building Information Modelling (BIM) software. BIM software is the most promising technology adapted in educational institutions, especially in the United Kingdom, USA and Australia (Abbas, Din & Farooqui, 2016).

Digitisation has affected many industrial sectors, and there is no exemption to education institutions, as the notion is towards providing new ways of learning. Among the Education 4.0 learning concepts and tools applied in the construction engineering education discipline are remote and virtual laboratories, educational robots (ERS), massive open online courses (MOOC), 3D virtual worlds and E-learning (Mogos *et al.*, 2018). In addition, new pedagogy methods such as blended learning flipped classrooms and bring your own device (BYOD) promote innovative learning techniques (Hussin, 2018). The adoption of chatroom learning tools in the current pedagogy offers good communication interactions between academicians and students at any time and place (Shahroom *et al.*, 2018). Previous research has proven that the use new pedagogy platform enhances students' understanding and knowledge, resulting in better test scores (Saxena et al.,. However, there is still a lack of studies that have identified the perceptions on Industry 4.0 and Education 4.0 in the Malaysian construction industry and educational institutions.

2. Methodology

The questionnaire survey method was adopted in this study. An extensive literature review was first conducted in designing the variables used in the quantitative method to enhance the validity and reliability of the survey (Fapohunda, Ph & Stephenson, 2014). Two sets of questionnaire surveys were prepared and distributed to the targeted respondents (industry players and academicians). A pilot survey was deployed to ensure that the questionnaire was comprehensive, explicit and rational to the aim of this study. The survey consisted of three main sections, which are demographic information, knowledge of Industry 4.0 and Education 4.0, and barriers to adopting digitisation in the construction engineering discipline. The first section requires the respondent to fill in information details such as age, academic qualification and years of practice. Secondly, the respondents' level of understanding and familiarity with their first knowledge of Industry 4.0 and Education 4.0 were measured. The third section consists of the respondents' responses towards Industry 4.0 and Education 4.0 challenges from the construction engineering perspective.

A total of 74 respondents were selected based on the purposive data sampling, where 42 respondents were from the construction industry and 32 academicians from Malaysian public universities. The industry players were selected based on the Publics Work Department (PWD) active projects in Malaysia with a project cost of more than MYR 100 million. The reason is due to the high possibility of adopting advanced technologies in such high-cost projects. For the industry players, the participants' designation were mainly engineers, project managers and project directors. Meanwhile, the academicians were chosen among the Construction Management Department in the Civil Engineering and Built Environment faculties in Malaysian public universities. Eight out of the ten public universities across peninsular Malaysia have cooperated to provide the feedback. This instrument was distributed through face-to-face and virtual methods via a google form. The data collected were analysed using the Statistical Package for the Social Sciences (SPSS) software.

3. Findings

The findings of this study are divided into three sections, which are demographic, awareness and challenges sections. This section presents the findings in addressing the purpose of this study, based on the input from the industry players and academicians on Industry 4.0 and Education 4.0 in construction. The type of analysis conducted to measure the characteristics of this study was the frequency and descriptive analysis. The Cronbach's alpha values were also used to measure the internal consistency of the data in this study. Hence, the value for the industry players were 0.905, and academicians were 0.933, which indicates an excellent internal consistency between both disciplines.

3.1 Demographic Information

The structured questionnaire survey distributed to the construction industry players and academicians who taught construction engineering subjects has resulted in the following findings. A total of 74 questionnaires were collected, with 42 responses (56.8%) from the construction industry player (IP) and 32 responses (43.2%) were academicians (A). Mostly, respondents from the industry sector were aged between 20–29 years old (38.1%), followed by 30–39 years old (33.3%), 40–49 years old (16.7%), and only 11.9% of respondents were more than 50 years old. Meanwhile, among the academician's group, the respondents' age was mainly between 40–49 years old (38.1%), followed by 30–39 years old (33.3%) and more than 50 years old (28.6%).

In terms of academic qualification, more than half of the industry players hold a bachelor's degree qualification (66.7%), followed by Diploma (21.4%), Masters (9.5%) and a PhD (2.4%). Most of the academicians have PhD qualifications (71.4%) and Masters (28.6%). The construction industry players' years of practice mostly ranges between 1–5 years (35.7%), 5–10 years (28.6%), 10–15 years (14.3%) with 19% of the respondents having more than 20 years of working experience. Generally, the academicians' years of practice were between 10–15 years (38.1%), more than 20 years (28.6%), 15–20 years (19.0%), 5–10 years (9.5%) and 1–5 years (4.8%). Table 1 summarises the demographic profiles of the respondents.

Table 1 - Demographic information

Category	IP (%)	A (%)
Age		
<19	0	0
20-29	38.1	0
30-39	33.3	33.3
40-49	16.7	38.1
>50	11.9	28.6
Academic Qualifications		
Certificate	0	0
Diploma	21.4	0
Degree	66.7	0
Master	9.5	28.6
PhD	2.4	71.4
Others	0	0
Years of Practice		
< 1 years	0	0
1 – 5 years	35.7	4.8
5 – 10 years	28.6	9.5
10 – 15 years	14.3	38.1
15 – 20 years	2.4	19.0
> 20 years	19.0	28.6

3.2 Awareness

The importance of Industry 4.0 and Education 4.0 adoption in the construction industry is vital to enhance the current knowledge, practice and skills for a better project life cycle and enhance the current pedagogy. Hence, in order to investigate the awareness of Industry 4.0 and Education 4.0 transformation among industry players and academicians, the level of knowledge on Industry 4.0 and Education 4.0 concepts were asked in the survey. Based on the findings, more than half of the industry players (73.8%) have heard about Industry 4.0, while the remaining 26.2% have never heard of the term. On the other hand, all academic respondents (100%) were aware of the Industry 4.0 term. The comparison of Industry 4.0 awareness between the different categories of respondents is shown in Fig. 1. In terms of duration of awareness, about 45.2 % of the industry players has heard about Industry 4.0 less than a year ago, followed by 1–5 years (35.7%) and none (19.0%). Meanwhile, the academicians have known the term from 1–5 years ago (78.1%), less than a year (18.8%) and more than five years (3.1%). The years of Industry 4.0 awareness shown by the respondents is presented in Fig. 2. Generally, some industry players (19%) and academicians (28.1%) have attended the Industry 4.0 and Education 4.0 training courses. Nonetheless, more than half of them did not attend any training courses on the subject matter. Fig. 3 shows the respondents who joined the Industry 4.0 or Education 4.0 training courses.

The source of knowledge among respondents has also been asked in the questionnaire survey. According to the industry players' responses, the most common source of information on Industry 4.0 were from the online media (26%), followed by conference, seminar or workshop (24%), print media (23%), construction industry (18%), tertiary institutions (8%) and others (1%). From the academic responses, the online media (22%) and tertiary institutions (22%) play an important role to deliver Industry 4.0 information. In addition, are the conference together with seminar or workshop (19%), construction industry (17%), print media (17%) and others (3%). Fig. 4 illustrates the percentage of Industry 4.0 sources of knowledge acquired by the industry players and academicians.

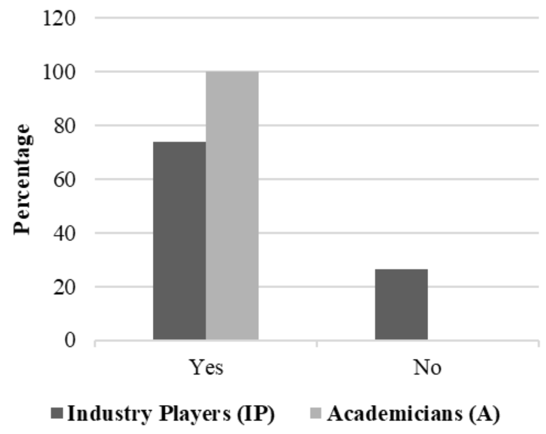

Fig. 1 - Awareness of the term Industry 4.0

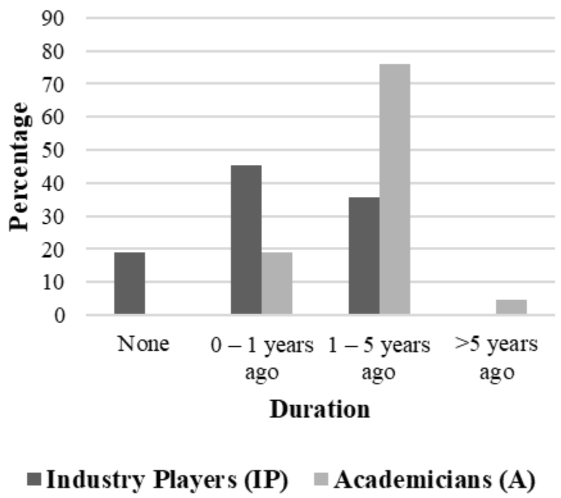

Fig. 2 - Duration of Industry 4.0 awareness among industry players and academicians

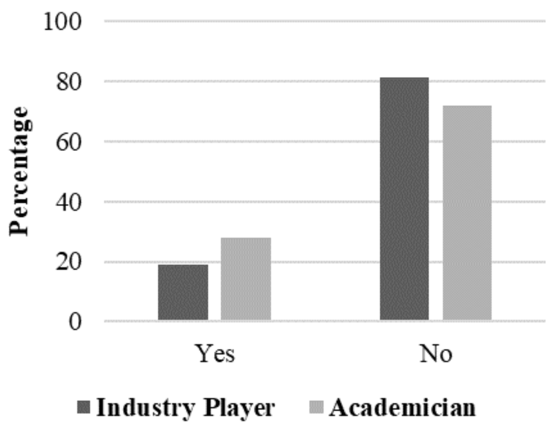

Fig. 3 - Respondents who have attended Industry 4.0 or Education 4.0 training courses

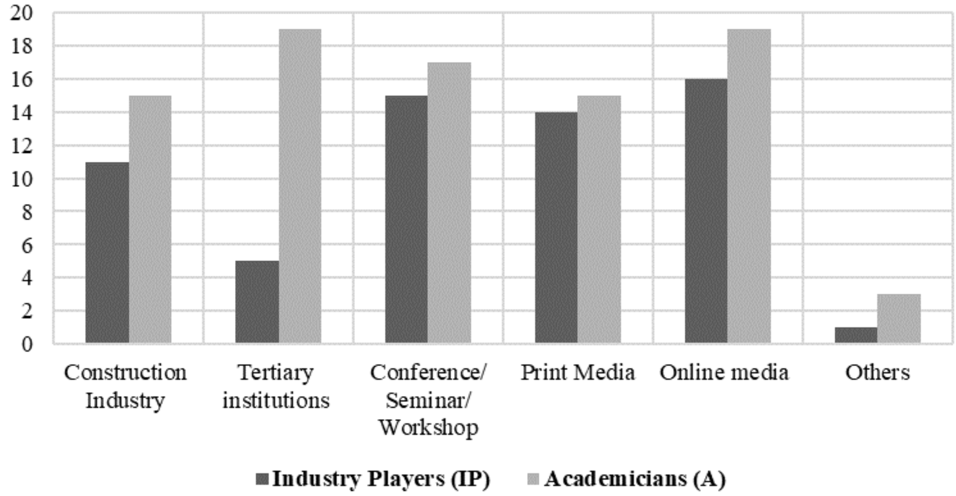

Fig. 4 - Industry 4.0 knowledge sources

The respondents were further asked to define Industry 4.0 based on four main definitions stated by the previous researchers. Table 2 describes the Industry 4.0 definitions by labelling each meaning with D1, D2, D3, D4 and others as D5. Based on the results, the D1 definition is the most selected meaning by industry players (39.0%) and academicians (38.0%). Subsequently, the industry players have selected D2 (25.0%), D3 (19.0%) and D4 (17.0%) as the following familiar definitions. Meanwhile, the academicians were more familiar with D3 (26.0%), followed by D2 (19.0%), D4 (11.0%) and others (6.0%). Fig. 5 shows the knowledge of Industry 4.0 definitions results.

Table 2 - Definitions of Industry 4.0

Definitions	Label
The introduction of the internet of things (IoT), services (IoS) and data (IoD) technology allow machines to manage themselves and use automation to computers, communication and the internet (Tay *et al.*, 2018).	D1
A new, emerging structure and integrated communications network for a widely automated exchange of information between production and processes (Rüßmann *et al.*, 2015).	D2
A combination between the real world, virtual world and traditional operations based on information and communication technology (ICT) adoption (Geissbauer, & Schrauf, 2014).	D3
A new level of organisation and control over the entire value chain of the life cycle of products, it is geared towards increasingly individualised customer requirements (Vaidya, Ambad & Bhosle, 2018).	D4
Others	D5

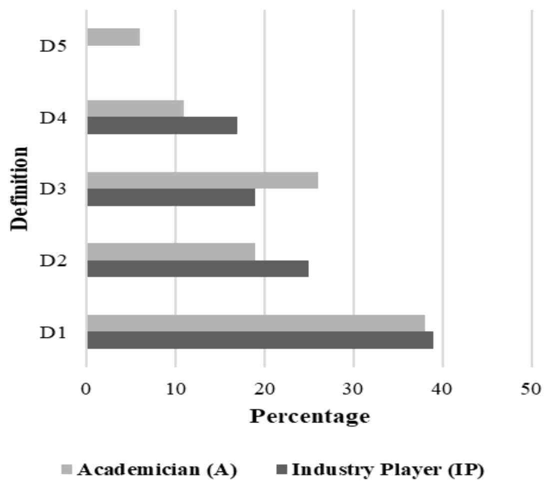

Fig. 5 - Knowledge on Industry 4.0 definitions

In order to assess the awareness of Industry 4.0 concepts and applications, the respondents were asked to rate their level of understanding of the Industry 4.0 concept and applications. The majority of the industry players (31%) and academicians (56.3%) acknowledged having a fair understanding of the Industry 4.0 concept from the construction engineering perspective, as shown in Fig. 6. Likewise, the level of knowledge on Industry 4.0 applications among industry players (28.6%) and academicians (50.0%) was also rated as fair. Only a few respondents among the industry players (2.4%) and academicians (6.3%) perceived to have an excellent understanding of the Industry 4.0 concept and applications. The findings are shown in Fig. 7.

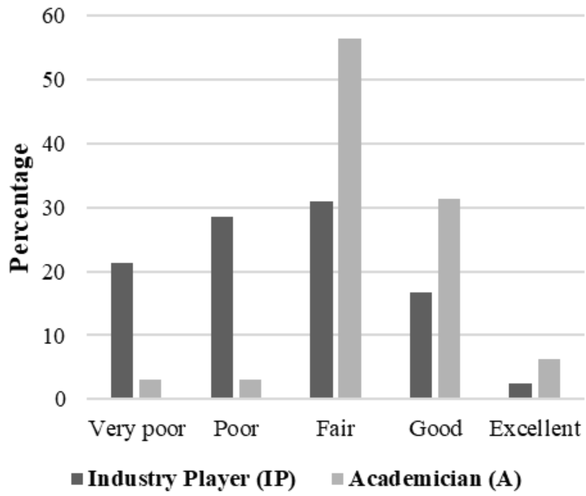

Fig. 6 - Level of Understanding on Industry 4.0 Concept

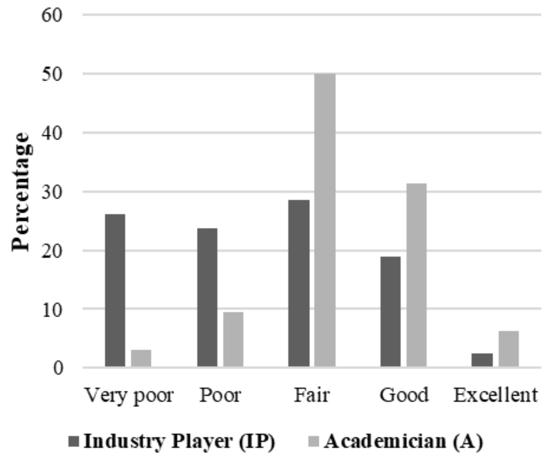

Fig. 7 - Level of Understanding on Industry 4.0 applications

Further on, the respondents' level of familiarity towards Industry 4.0 components were measured using the Likert scale, from 1 (not familiar at all) to 5 (extremely familiar). According to the findings, both respondents are most familiar with the Building Information Modelling (BIM) with the mean values of industry player (IP) = 3.71 and academicians (A) = 4.13. Meanwhile, the lowest familiarity of Industry 4.0 components among industry players and academicians were cyber-physical systems (CPS) or embedded systems (IP = 2.33 and A = 2.41). The remaining results of the respondents' level of familiarity with Industry 4.0 components are illustrated in Fig. 8.

The Education 4.0 applications' rate of familiarity was asked specifically to the academicians. This is because the industry players were not directly involved with any educational applications. Flipped classroom, blended learning and brought your own device approach (BYOD) are the most familiar applications among the academicians (m=3.81). The least familiar applications among the academicians were the educational robots (ERS), with the mean value, m=3.10. The level of familiarity for other Education 4.0 applications are presented in Fig. 9.

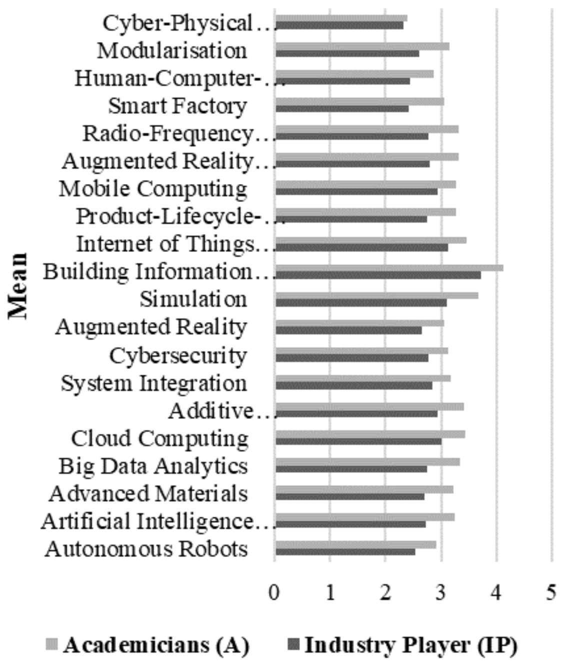

Fig. 8 - Level of familiarity with Industry 4.0 technologies

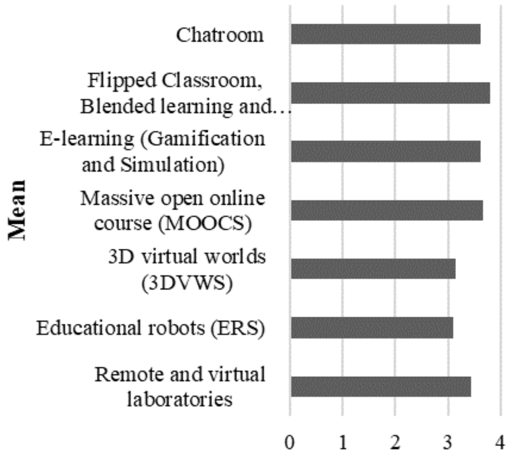

Fig. 9 - Level of familiarity towards Education 4.0 applications

3.3 Barriers

In this section, the respondents were asked to rate the significance of the listed barriers towards adopting Industry 4.0 in the construction industry, from 1-strongly disagree to 5- strongly agree. Results on the industry players and academicians' perceptions towards the barriers were tabulated in Table 3, in the form of mean (m) value. Based on the results, the main barriers highlighted by both the industry players (m = 4.02) and academicians (m = 4.13) were financial constraints. This is followed by the lack of general knowledge about Industry 4.0 among the industry players (m = 3.86) and academicians (m = 3.97). Meanwhile, the least contributing factor as barrier among industry players was the complexity of software and technology (m=3.67). The academicians' opinion on the least critical factors to Industry 4.0 adoption was poor management support (m=3.19).

Table 3 - Perceptions on the barriers to adopting Industry 4.0

	Mean (m)	
	IP	**A**
Financial constraints	4.02	4.13
Lack of general knowledge	3.86	3.97
Lack of government support and strategies	3.79	3.53
Poor management support	3.76	3.19
Lack of standards and guidelines (Legal)	3.74	3.72
Bureaucracy obligations issues (Enforcement)	3.74	3.78
Lack of collaborations with other stakeholders	3.71	3.38
High risk of data manipulation or plagiarism	3.71	3.88
Limitation of technology platform	3.69	3.41
Software legal issues	3.69	3.81
Data privacy concerns	3.69	3.84
Complexity of software & technology	3.67	3.94

4. Discussion and Conclusion

Findings on the awareness of Industry 4.0 and Education 4.0 shows similarities, as well as differences between the two categories of respondents, namely industry players and academicians. Although Industry 4.0 has been introduced since year 2011 by the German Government, most of the respondents were only aware of the technological transformation in late 2015. This is in light of the Malaysian government's official introduction to Industry 4.0 in the year 2015 through the release of the Construction Industry Transformation Programme (CITP) 2016-2020. Generally, the entire academicians were aware of Industry 4.0 and Education 4.0 concepts because of the nature of their work, in seeking for new knowledge and to further adopt and adapt new technologies in current pedagogy. All respondents agreed to most of the classification of definitions for Industrial Revolution 4.0, although some of the industry players were not aware of this transformation. Currently, a large number of simulations software is available in the market. It is probably one of the leading factors for the familiarity of BIM applications among both categories of respondents. The industry players and academicians have provided similar responses and perceived financial constraint as the most critical barrier in adopting Industry 4.0 and Education 4.0 since the economic factor could be the driving or distracting force of change in organisations.

5. Limitation and Future Research

This study has investigated the insights between the perceptions of industry players and academicians in the construction engineering discipline. Nonetheless, the use of the purposive sampling method makes the findings less generable but addresses the notion of this study. Hence, the scope of this study could be extended to include other construction industry players (private organisations, projects of lower cost, other construction stakeholders) and academicians in related fields beyond construction engineering (quantity surveying, architectural, civil engineering).

References

Abbas, A., Din, Z. U., & Farooqui, R. (2016). Integration of BIM in construction management education: an overview of Pakistani Engineering universities. Procedia Engineering, 145, 151-157

Baena, F., Guarin, A., Mora, J., Sauza, J., & Retat, S. (2017). Learning factory: The path to industry 4.0. Procedia manufacturing, 9, 73-80

Coşkun, S., Kayıkcı, Y., & Gençay, E. (2019). Adapting engineering education to industry 4.0 vision. *Technologies*, *7*(1), 10

Department of Higher Education Malaysia (2018) Framing Malaysian Higher Education 4.0: Future-Proof Talents

Fapohunda, J. A., & Stephenson, P. (2011). Knowledge, attitude, and perception (KAP) of construction participants towards resource waste in the construction industry. The Pacific Journal of Science and Technology, 12(2), 284-299

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. International Journal of Education and Literacy Studies, 6(3), 92-98

Mogoş, R. I., Bodea, C. N., Dascălu, M. I., Safonkina, O., Lazarou, E., Trifan, E. L., & Nemoianu, I. V. (2018). Technology-enhanced learning for industry 4.0 engineering education. Rev. Roum. Sci. Techn.–Électrotechn. et Énerg, 63(4), 429-435

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. Computers in industry, 83, 121-139

Osunsanmi, T. O., Aigbavboa, C., & Oke, A. (2018). Construction 4.0: the future of the construction industry in South Africa. International Journal of Civil and Environmental Engineering, 12(3), 206-212

Philipp Gerbert, S. C. C. R. & A. R. (2016). Shaping the future of construction a breakthrough in mindset and technology, World Economic Forum (WEF), pp. 1–64. Available at: https://www.bcgperspectives.com/Images/Shaping_the_Future_of_Construction_may_2016.pdf

Saxena, R., Bhat, V., & Jhingan, A. (2017). Leapfrogging to education 4.0: student at the core. FICC Higher Edu cation Committee

Geissbauer, R., Schrauf, S., Koch, V., & Kuge, S. (2014). Industry 4.0–Opportunities and challenges of the industrial internet assessment. PricewaterhouseCoopers. URL: https://www. pwc. nl/en/assets/documents/pwc-industrie-4–0. pdf

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. Boston Consulting Group, 9(1), 54-89

Seres, L., Pavlicevic, V., & Tumbas, P. (2018, March). Digital transformation of higher education: Competing on analytics. In Proceedings of INTED2018 Conference 5th-7th March (pp. 9491-9497)
Shahroom, A. A., Hussin, N., Shahroom, A. A., & Hussin, N. (2018). Industrial Revolution 4. 0 and Education, 8 (9), 314–319

Ślusarczyk, B. (2018). Industry 4.0: Are we ready?. Polish Journal of Management Studies, 17

Tay, S. I., Lee, T. C., Hamid, N. Z. A., & Ahmad, A. N. A. (2018). An overview of industry 4.0: Definition, components, and government initiatives. Journal of Advanced Research in Dynamical and Control Systems, 10(14), 1379-1387

Vaidya, S., Ambad, P., & Bhosle, S. (2018). Industry 4.0–a glimpse. Procedia Manufacturing, 20, 233-238. Xue, X. et al. (2014) 'Innovation in construction: A critical review and future research, International Journal of Innovation Science, 6(2), pp. 111–125