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THE READINESS OF PUBLIC UNIVERSITIES IN ADOPTING INDUSTRIAL REVOLUTION 4.0 (IR 4.0) FROM A CONSTRUCTION MANAGEMENT PERSPECTIVE

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Graphical abstract

Abstract

There have been four major Industrial Revolutions that have developed human lifestyles. Currently, the Fourth Industrial Revolution, (IR 4.0), is taking place in major industries with current students and graduates requiring new talents and skills to become a future-proof workforce. However, current tertiary education is not yet fully equipped to deal with IR4.0 concepts. This results in the low awareness of IR4.0 among students and graduates where they are not yet ready to enter an IR4.0 workspace. This is especially so in construction management education. Hence, the aim of this research is to improve existing construction engineering education by including IR4.0. This research is based on data collected from a survey by questionnaire responses from construction management undergraduate and postgraduate students at Universiti Teknologi MARA (UiTM) Shah Alam. The findings show that these construction management students agreed that challenges such as the traditional construction management curricular structure and the lack of IR4.0 facilities hindered the implementation of IR4.0 in construction management education. Therefore, recommendations such as the collaboration of industry experts with universities and students to enable the adoption of IR4.0 into project-based learning were discussed. In conclusion, this study hopes to help both universities and students to be prepared for the integration of and benefits from, implementing IR4.0 in construction management education.

Keywords: Education, Innovative learning, robotics, Technological readiness

1.0 INTRODUCTION

There have been four major industrial revolutions that have changed and evolved the way that humans live. The first Industrial Revolution can be traced back as far as 200 years ago during the late 18th century in Great Britain where water and steam-powered machines were used initially in textile industries [1]. Meanwhile, the Second Industrial Revolution, the Technological Revolution, began during the late 19th century to early 20th century. During this period, Henry Ford redesigned his US factory by eliminating all unnecessary human motion following the invention of the conveyer belt [2]. Then, the Third Industrial Revolution was a huge leap ahead wherein the advent of the computer and automation ruled the industrial scene [3]. During this period, technologies such as robots were used to perform tasks that were previously performed by humans. Currently, the Fourth Industrial Revolution (IR 4.0) is taking place in major industries. It was first introduced in 2011 where the concept of a combination between physical and digital systems, known as a cyber-physical system, originated in Germany [4].
In conjunction with IR 4.0, the term Education 4.0 has also become popular among the public and education practitioners

[2]. This is due to the parallel between IR 4.0 and Education 4.0 where IR 4.0 demanded that the education sector to provide an adequate workforce with skills to work in an IR 4.0 workplace environment. Correspondingly, the gap between Education 4.0 and IR 4.0 needed to be explored to identify the current applications used from a construction management education perspective [5]. As the pace of innovation and convergence towards IR4.0 demands new talents, expertise, and skills for current and future generations, existing tertiary education needs to change accordingly to accommodate future job demands [5].

2.0 INDUSTRIAL REVOLUTION 4.0 (IR4.0)

The concept of Industrial Revolution 4.0 (IR4.0) has gained great importance in recent years. The use of increasing numbers of computerized applications has required the creation of more robust digitized systems and integrated networks that enable the replacement of human beings for certain tasks whilst supporting human/computer integration in the workplace [6]. The term IR4.0 itself indicates that there have been three (3) industrial revolutions prior to IR4.0. The first industrial revolution took place from about 1760 to 1830 where the rapid growth in mechanical heavy industries lead to the creation of building materials such as cast iron and steel [1]. The second industrial revolution started around 1870 until 1914 where mass production became more efficient and cheaper along with the increased use of electricity and the invention of the telephone. The third industrial revolution, also known as the Digital Revolution, began in the latter half of the 20th century and introduced the internet, information technology, and the availability of personal computers. The Digital Revolution started the relationship between technology and construction with 3D computer-aided design (CAD) helping architects to improve and produce precise designs [1]. Figure 1 below shows an overview of the Industrial Revolutions

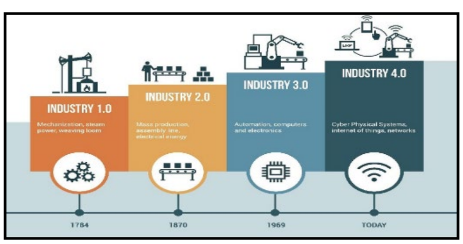

Figure 1. Overview of the industrial revolutions [7]

IR 4.0 is first originated in Germany in 2011 as a key strategic initiative for German industries in the manufacturing sector out [8]. Since then, its immense technological potential has been increasingly pointed out [8]. The term IR4.0 in the manufacturing sector can be described as the increasing digitisation and automation of the manufacturing environment as well as the creation of a digital value chain to enable the communication between products and their environment. The concept of IR4.0 is so widely used, that it can also be defined as a change driven by physical, digital, and biological factors that can affect human life and relationships in terms of the ways that people live and work [9]. Meanwhile, in the construction industry, [8] define IR4.0 as a plethora of interdisciplinary technologies to enable the digitisation, automation, and integration of the construction process at all stages of the construction value chain. Although IR4.0 was firstly invented for the manufacturing sector, the IR4.0 concept can be applied in other sectors where digitisation and automation are widely used.

3.0 EDUCATION 4.0

Similar to IR4.0, the education revolution is also categorized based on the levels through which it has evolved in the past centuries with the teaching and learning process evolving alongside the development of technology [2]. Prior to the 1990s, the Education 1.0 learning process happened in classrooms where the teacher acted as the knowledge source with the students as the knowledge receivers. With the early development of the World Wide Web, the source of knowledge began slowly shifting to the internet for retrieving information [10]. However, during that time access to the internet was still quite limited. Then, the second education revolution, Education 2.0, started in the 2000s with the boom in internet usage with the introduction of the early social media and interaction of users on the internet [11]. The progression of Education 2.0 resulted in knowledge transfers not only from teacher to students but also from student to student. The third education revolution, Education 3.0, started in the 2010s and is currently being used. The teaching methods widely involved technology as the medium for receiving and transferring knowledge [2]. Education 3.0 also changes how classrooms work with the change of traditional lectures to the interaction-focused classroom.

Ever since the rise of Industrial Revolution 4.0, the industry has demanded more qualified candidates who can work in a new working environment. The education sector, the provider of such candidates, will have to find new ways to train students to prepare them for an IR4.0 working environment [5]. Thus, the term Education 4.0 was coined as the starting point for the education system to reorganise to embrace IR4.0. The characteristic of Education 4.0 is the personalized learning experience where students has the ability to learn however they see fit [12]. To fill this gap, both the construction industry and the education sector need to collaborate to confront these rapid changes and obligate meeting the demands of the IR4.

3.1 Implementation of IR4.0 in Education

Industry 4.0 and Education 4.0 both deal with the developments of technologies and the abundance of information excess. This also adopts the notion that the future workforce and today's students need to be exposed to both IR4.0 and Education 4.0 [13]. Nowadays, data and information are readily accessible and immediately to hand, thus students can learn beforehand rather than in classes. Ahmad Yusof et al (2019) added that Education 4.0 presumes that today's learners are very different as they would rather access the knowledge of their own free will instead of having knowledge spoon-fed to them. Therefore, most industry experts believed that some careers will eventually be substituted by these developing IR4.0 technologies [14].

As IR4.0 advances have introduced a new profession to meet the current demands of industry, the education sector is driven by the need for experienced, highly skilled, and prepared graduates only. [14] argued that experts suggested that there are three key critical technical skill themes required for IR4.0: data analysis, interpretation, and documentation; process understanding and optimization; and system execution, troubleshooting, and device maintenance. In this context, construction education, like any other technical education, needs to remain up to date with today's technologies, especially those linked to IR4.0. Importantly, of the nine main pillars of IR4.0, almost all apply to the construction industry. Thus, students and the future workforce need to be ready to face this digital age.

3.1.1 Visualizing BIM, Augmented Reality (AR), and Virtual Reality (VR) as Mixed Reality (MR)

Building Information Modelling (BIM) is a tool to increase the efficiency of design communication and collaboration between project team members. According to [15], students nowadays are characterised as being more in favour of visual media learning than listening or reading. In order to realize the full potential of these new opportunities, a simultaneous change in CM education is required, and the implementation of BIM in the curriculum offers numerous benefits for construction project management education. In addition, BIM also provides students with direct learning benefits and skills development which are increasingly becoming standard industry practice.

As BIM has further developed, Augmented Reality (AR) is now commonly adopted as support for BIM to visualize the models interactively. [15] further points out that with AR, students will have a better understanding due to their engaging and immersive interaction with the 3D objects. This is supported by [16] where the simulation of BIM using AR technologies offers construction education students a more practical sense of materials, project issues, and decision-making processes. Building education students can better use BIM and AR as a platform that can further enhance teamwork and communication within and between various phases of a project [16].

Mixed Reality (MR) is a technology that allows the physical world to be enhanced through AR and Virtual Reality (VR) using immersion, interactions, information, and systems based on environments, users, and the level of virtuality [15]. In AEC education, MR can be combined with smartphones to enable learning in new dimensions, leading to more realistic experiences and increasing students' engagement and enthusiasm [15]. MR will help students and users navigate BIM data in an interactive virtual space and evaluate aspects such as cost and materials in real-time to improve successful building design [17]. In general, the combination of BIM, AR, and VR can enhance and empower current students to better coordinate design and operation over a project lifecycle and improve overall project performance.

3.2 Previous Studies on Students' Readiness on IR4.0 and Education 4.0

The recent emergence of IR4.0 and Education 4.0 has led to various studies of readiness among students, lecturers, and institutions in embracing the benefits of implementing the technologies and concepts of IR4.0 and Education 4.0. [18] described readiness as the state of readiness of an individual, system, or organization to face a situation and carry out a planned set of actions. Other than that, [14] conduct a study on the readiness among Universiti Tun Hussein Onn Malaysia (UTHM) Technical and Vocational Education and Training (TVET) students in facing the challenges of IR4.0 based on three (3) main factors which are knowledge factor, skills factor and attitude factor. The study's overall conclusion indicates that the students had a relatively poor understanding of IR4.0. This can be due to the students are unlikely to be accustomed to using IR 4.0 technology during teaching and learning sessions in class or in everyday life. However, his study found that students are ready and willing to face the challenges of IR4.0. To combat the challenges of IR4.0, he added that, institutions and educators need to review and restructure the existing curriculum with the objective to produce graduates that are IR4.0 ready as well as reskilling and upskilling the educators, especially senior lecturers. Similarly, a recent study done by [19] in Malaysia indicated that students are ready to embrace Education 4.0 and show positive attitude incorporating technology in learning but were hindered with a lack of technology facilities.

In addition, another study similarly done in South Korea by [20] showed that the term IR4.0 is commonly spoken by students, but they still lack a deeper understanding of its concept. This could be due to IR4.0 concepts and technologies are not yet incorporated in the higher education institutions' curriculum [20]. This study also showed that students have limited familiarity on the Internet of Things (IoT) whereas technology such as 3D Printing was the most familiar among the students. To some degree, the study also found that the perspectives of IR4.0 are different among gender. The author presumed that it might be that male students are more exposed and more interested in IR4.0 technologies. Furthermore, another similar study done in Vietnam by [21] shows that students who had experienced online-based learning had higher readiness for Education 4.0 compared to those who had not experienced online-based learning. In conclusion, these studies show that students are in the know of the IR4.0 trend and ready to face IR4.0 as well as Education 4.0 although gave limited knowledge in regards to IR4.0 but were hindered by the lack of facilities and support from institutions and educators.

3.3 The Current Status of Education and IR 4.0 in Malaysia

In 2020, a study conducted by Malaysia's Ministry of Education (MOE) shows that although 51,000 students graduate each year, almost 60% remain unemployed a year after graduating. This is because some of the courses on offer are no longer in demand and graduates must compete for their place in this fast-paced economy [22]. To overcome this, the director general of the Higher Education Department required lecturers to redesign and introduce new courses to include IR4.0 to ensure their relevance [23]. As of now and with an awareness of IR 4.0, Malaysia is in the stage of preparing Education 4.0 as part of the campaign to redesign the system by creating Malaysia's Education Blueprint 2020-2025 [2].

This can be supported by a study from INTI University and International Data Corporation (2019) that shows 63% of students and graduates were not able to explain what IR4.0 was [23]. The study also revealed that 30% of students felt unprepared for IR4.0 workspaces in which technological skills are applied to support innovation and progress. 28% of students said the only time they were exposed to IR4.0 was during university days, which shows that students and graduates rely on their institutions to provide them with the necessary preparation for IR4.0 [23].

On 31 October 2018, the Malaysian government launched a national policy on IR4.0 through Industry4WRD to drive the digital transformation of the manufacturing sector as well as other related services [24]. The Industry*4WRD* is said as a national policy that aims to transform the manufacturing sector and related services within the period from 2018 to 2025. This policy consists of a strategic partner for smart manufacturing and related services in the Asia Pacific, the primary destination for investment in the high technology industry; and a total solutions provider for cutting-edge technology [24]. In upholding IR4.0 with the Industry4WRD policy, UiTM launched the Pioneering University Framework to put forward High End Technical and Vocational Education Training (TVET) courses to introduce emerging technology competencies into their courses [23]. It is said that most courses have been revised to include any IR4.0 applications. Such courses can be identified in the Faculty of Electrical Engineering. However, the government Industry4WRD policy only focuses on the manufacturing industry rather than the construction industry [24]. As of today, undergraduate, and postgraduate construction management courses are yet to fully integrate IR4.0 applications despite the new framework. According to Maria et al. (2018), such IR4.0 applications are more pronounced in electrical, mechanical, and architectural courses rather than in civil engineering and construction management courses.

As IR 4.0 has become established in the education sector, industries will demand more qualified candidates who can work in this new era of the industrial revolution. Thus, the education sector will have to adjust its training methods in order to prepare students. Hence, this research aims to improve the existing construction management education by adopting IR4.0 applications.

4.0 METHODOLOGY

Data on students' insights were collected by using a survey by questionnaire. The selected respondents for this survey were the final year undergraduate and postgraduate construction management students from Universiti Teknologi MARA, Shah Alam. The total number of students was 124 made up of 96 undergraduate and 28 postgraduate students. The sampling model for this research was based on the Krejcie and Morgan Model (1970) to estimate how many sets of questionnaires needed to be distributed and showed that the total sample size needed for this research should be between 92 and 97. Questionnaire surveys were used for this research as it is a common method that is being used to gather data from large sampling related to this topic [25] [26] [27] [28]. For this research, data analysis using descriptive statistics was carried out using Statistical Package for the Social Sciences (SPSS). This procedure is effective when sampling involves the majority of, or the entire, respondent population.

The final questionnaire was designed to answer the following research objectives: 1) to review the respondents' background, 2) to identify the challenges in integrating IR4.0 within construction management education, and 3) to recommend the best ways of integrating IR4.0 technologies related to construction management education. The questionnaire was designed with the collected data from literature reviews on the definition of IR4.0, the challenges of integrating IR4.0 in education, and the recommendation to apply IR4.0 in education. From here, the researcher is able to rank the returned questionnaires. Table 1 below shows the sources of the questionnaire design.

Table 1. Summary of Questionnaire Design

Section	Aim	Sources
Section B	Challenges of integrating IR4.0 in construction management education	[29] [30] [31] [28] [32]
Section C	Recommendation ways of integrating IR4.0 in construction management education	[33] [34] [35] [36] [14] [37]

The gathered data were analysed using a Descriptive and Reliability test using Cronbach's alpha coefficient. Generally, a score of more than 0.7 is considered acceptable [38]. The questionnaire required open-ended and Likert scale responses to measure the reaction of respondents [39]. Open-ended questions were used to gather the respondent backgrounds while the Likert scale was used to measure the respondents' degree of agreement with a question/statement.

4.1 Results and Discussion

From the total of 124 questionnaires distributed, 99 answered questionnaires were received, which represents a 79.8% response. The gathered data shows the challenges of integrating IR4.0 in construction management education as well as the recommendations on how this integration could be achieved. The challenges and recommendations were analysed from two perspectives: the student perspective and the university and lecturers' perspective.

4.1.1 Challenges of IR4.0 Integration in Education

Table 2. Reliability Test Results for Challenges of IR4.0 Integration in Education

Challenges of IR4.0 integration in education	Cronbach's Alpha	N of items	Reliability Level
Challenges to Universities and Lecturers when Integrating IR4.0 in CM Education	.816	5	Good

Challenges of IR4.0 integration in CM education from the students' perspective	.784	5	Acceptable

The results of the reliability analysis were carried out on the challenges of IR4.0 integration in education comprising two (2) sections with 5 items each. Cronbach's alpha showed the questionnaire to reach good and acceptable reliability of α = .816 and α = .784 respectively as in Table 2.

Table 3. Ranking of the Challenges to Universities and Lecturers when Integrating IR4.0 in CM Education

Challenges to Universities and Lecturers when Integrating IR4.0 in CM Education.	Mean	Std. Deviation	Ranking
Traditional CM education curriculum structure that lacks an emphasis on IR4.0 technologies.	4.1414	.70000	1
The difficulty of lecturers adopting new technologies due to limited understanding and skills.	4.1111	.79397	2
Poor internet access provided by the university for lecturers leading Online Virtual Classes.	4.0909	.90453	3
Awareness of IR4.0 among lecturers is still low.	3.8485	.92982	4
Lecturers' lack of interest in using technologies related to IR4.0 in the classroom.	3.8182	1.07251	5

Table 3 above shows the ranking of the challenges to universities and lecturers in integrating IR4.0 within CM education. Five challenges were laid down of which the highest-ranking was 'Traditional CM education curriculum structure that lacks an emphasis on IR4.0 technologies' with a mean of 4.14. The second highest-ranking challenge was 'Difficulty of lecturers adopting new technologies due to limited understanding and skills' with a mean of 4.11. The third highest rank was 'Poor internet access provided by the university for lecturers leading Online Virtual Classes' with a mean of 4.09. Next came 'Awareness of IR4.0 among lecturers is still low' with a mean of 3.85. Lastly, 'The lack of interest of lecturers in using technologies related to IR4.0 in the classroom' ranked lowest with a mean of 3.82. Therefore, from the data, it can be concluded that currently, lecturers and universities are aware of IR4.0 and the benefits of adopting it in education. Overall, however, these challenges are connected since the traditional CM curricular structure remains in place due to the difficulties of educators in adjusting to new technologies and also the lack of internet connectivity within the campus environment.

Table 4. Ranking of the Challenges of IR4.0 Integration in CM Education from the Students' Perspective

Challenges of IR4.0 Integration in CM Education from the Students' Perspective.	Mean	Std. Deviation	Ranking
The lack of IR4.0-related facilities in university such as 3D Printers and VR head-mounted displays.	4.4040	.60473	1
Poor internet access is provided by the university for students in Online Virtual Classes.	4.2828	.55403	2
Awareness of IR4.0 among students remains low.	4.2424	.80927	3
Poor interaction among students while using Online Virtual Classroom learning tools.	4.1616	.71009	4
Students are not tech-savvy and up-to-date with the latest technologies.	3.9495	.98327	5

Table 4 above shows the ranking for the challenges of IR4.0 integration in education from students' perspectives. The highest-ranking is '*The lack of IR4.0 related facilities in University such as 3D Printer and VR head-mounted display*' with a mean of 4.40. According to [28], due to the lack of necessary facilities and technical supports, educators are force to have negative perceptions towards the implementation of new concepts or technology. Supported by [31], IR4.0 requires the university to have advanced infrastructure and facilities to support the digital transformation of IR4.0.

The second-highest ranking for challenges as according to students is '*Poor internet access provided by the university for students for Online Virtual Classes*' with a mean of 4.28. This is in line with [40] where he stated that students are having hard times with general internet access and virtual classes due to limited internet access inside the campus environment. '*Awareness of IR4.0 among students is still low*' is placed third in the ranking with a mean of 4.24. The lack of awareness from students may be due to the recent introduction of IR4.0 concepts and there is still confusion on IR4.0 terms and concepts [30]. This is then followed by the '*Poor interaction among students while using Online Virtual classroom learning tools*' at rank four with a mean of 4.16.

Finally, '*Students are not tech-savvy and up-to-date with latest technologies*' with a mean of 3.95 ranked at fifth. These data show that there is a connection between the challenges or integrating IR4.0 from students' perspectives. Therefore, from these data, it can be said that the students' perspective on the challenges of integrating IR4.0 in CM education can be due to the lack of facilities that emphasis on IR4.0 technologies and the lack of internet connectivity inside the campus environment that in return not giving enough awareness to the students regarding IR4.0.

4.1.2 Recommendation to Integrate IR4.0 in CM Education

Table 5. Reliability Test Results for Recommendation to Integrate IR4.0 in CM Education

Recommendation to Integrate IR4.0 in CM Education	Cronbach's Alpha	N of items	Reliability Level
Recommendations for Universities and Lecturers when Integrating IR4.0 in CM Education	.942	6	Excellent
Recommendations to Integrate IR4.0 in CM Education from the Students' Perspective	.944	7	Excellent

The results of the reliability analysis were carried out on the recommendation to integrate IR4.0 in CM education comprising two (2) sections. Cronbach's alpha showed the questionnaire to reach excellent reliability of α = .942 and α = .944 respectively as in Table 5.

Table 6. Ranking of Recommendations for Universities and Lecturers when Integrating IR4.0 in CM Education

Recommendation for Universities and Lecturers when Integrating IR4.0 in CM Education.	Mean	Std. Deviation	Ranking
Collaboration with industry to promote IR4.0 to students and academicians.	4.4343	.59181	1
Educators to attend training courses to be equipped with IR4 technologies.	4.3939	.76689	2
Use Digital Media and computer-based tools to disseminate knowledge such as AR, VR and BIM.	4.3131	.69498	3
Generalized Blended Learning in physical and online classrooms.	4.3131	.70922	4
Educators' self-efficacy with IR4 knowledge and technologies.	4.3131	.75114	5
Collaborative learning among students with other students from different universities.	4.2525	.73323	6
Globalizing Online Learning as an integral component such as by using MOOC (Massive Open Online Courses) and Google Classroom.	4.2323	7.8022	7

Table 6 above shows the data ranking for the recommendation for universities and lecturers to integrate IR4.0 in CM education. Seven recommendations were introduced based on literature reviews. The data analysis indicated that the highest-ranking was 'Collaboration with industry to promote IR4.0 to students and academicians' with a mean of 4.43. The second highest-ranking recommendation was 'Educators to attend training courses to be equipped with IR4 technologies' with a mean of 4.39. Next, the third rank is the 'Use Digital Media and computer-based tools to disseminate knowledge such as AR, VR and BIM' with a mean of 4.31. The fourth-ranking with a mean of 4.31 is 'Generalized Blended Learning in physical and online classrooms. The two lowest-ranking recommendations are 'Collaborative learning among students with other students from different universities with a mean of 4.25 and 'Globalizing Online Learning as an integral component such as by using MOOC (Massive Open Online Courses) and Google Classroom' with a mean of 4.23. Therefore, from these data, it can be concluded that collaboration with industry experts able to expose educators and students to the IR4.0 concept may encourage educators to attend IR4.0 workshops and seminars on computer-based tools such as BIM, AR and VR.

Table 7. Ranking of Recommendations to Integrate IR4.0 in CM Education from the Students' Perspective

Recommendation for universities and lecturers to integrate IR4.0 in CM education.	Mean	Std. Deviation	Ranking
Students to apply IR4.0 technologies such as BIM, AR and VR in project-based assessments.	4.2828	.79591	1
Student self-efficacy with, and awareness of, IR4.0 technologies.	4.2727	.63597	2
Students to be ready to adapt to the new technologies and information introduced by lecturers.	4.2626	.79006	3
Students to recommend that university management provide adequate IR4.0-related facilities such as 3D printers, wearable technologies and BIM-related software.	4.2626	.80288	4
Students to attend seminars and workshops on IR4.0-related technology topics on their own.	4.2222	.77664	5
Students to be wary with communication technologies and their importance such as Virtual Online classes and MOOC (Massive Open Online Courses).	4.2020	.79514	6

Table 7 above shows the data analysis ranking for recommendations to integrate IR4.0 in CM education from the students' perspective. It indicates that the highest-ranking is 'Students to apply IR4.0 technologies such as BIM, AR and VR in project-based assessments' with a mean of 4.28. The second-highest ranking is 'Student self-efficacy with, and awareness of, IR4.0 technologies' with a mean of 4.27. The third highest-ranking is 'Students to be ready to adapt to the new technologies and information introduced by lecturers' with a mean of 4.26. Next, the fourth rank is 'Students to recommend university management to provide adequate IR4.0-related facilities such as 3D printers, wearable technologies and BIM-related software' with a mean of 4.26. The second-lowest in fifth place is 'Students to attend seminars and workshops on IR4.0-related technology topics on their own with a mean of 4.22. Lastly, the lowest rank with a mean of 4.20 is 'Students to be wary with communication technologies and their importance such as Virtual Online classes and MOOC (Massive Open Online Courses)'. In conclusion, it is recommended that student self-efficacy in adopting the technologies of IR4.0 should be encouraged, such as adopting it into current project-based learning, keeping on the lookout for any new trends, and to always being ready to support educators introducing new IR4.0 technologies.

5.0 CONCLUSION

In conclusion, the study shows that the respondents agreed on the challenges of integrating IR4.0 in construction management education. This study found that universities and lecturers are aware of the concept and benefits of IR4.0 yet the traditional curricular structure practices hindered the adoption of IR4.0 due to the difficulties of lecturers in adjusting to new technologies and also the lack of internet connectivity. This can be supported by [28] who revealed that new technologies and concepts make it hard for educators to try to adapt and adopt them into their teaching and learning processes. On the other hand, students are not yet ready to embrace IR4.0 due to the lack of IR4.0 facilities and limited internet access within the campus environment. This in turn contributes to the low awareness of IR4.0 among students.

To combat these challenges, both universities and lecturers need to play their role by implementing the government initiative through, for example, collaborating with industry experts on knowledge and technology transfer. This in return may be the driving force for lecturers to achieve self-efficacy by attending IR4.0-related workshops and seminars. Alternatively, students are recommended to adopt IR4.0-related technologies and keep a lookout for new trends by themselves. This can be done by integrating IR4.0 technologies and tools such as BIM and VR within project-based learning. The use of BIM, AR, VR, or 3D printing in project-based learning allows students to have a better understanding of the complexity of the construction process [36].

Further research on this topic can be broadened by undertaking comparative research on the implementation of IR4.0 in public and private universities. Other than that, future research can also concentrate on AEC lecturers' perspectives on the readiness of IR4.0 implementation in AEC education in Malaysian public universities using a qualitative approach. Lastly, further research on the effectiveness of IR4.0 facilities among public and private universities should also be considered. This comparative research on the implementation of IR4.0 in different institutions can improve the current level of IR4.0 inclusion in tertiary education.

6.0 LIMITATION

The respondents for this research are only limited to UiTM Shah Alam final year Construction Management undergraduate and postgraduate students. There are limitations of reference in finding literature reviews such as journal articles, proceeding papers and publications on IR4.0 from students' perspectives. Further studies could be done focusing on the implementation of IR 4.0 in public universities in Malaysia.

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