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MEASURING TEACHERS' KNOWLEDGE ON THE APPLICATIONS OF THE NINE PILLARS OF THE FOURTH INDUSTRIAL REVOLUTION (4IR) IN EDUCATION

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ABSTRACT

The Fourth Industrial Revolution (4IR) refers to the current rapid technological growth that fundamentally changes how humans live. 4IR is essential to improve higher education worldwide and develop crucial skills such as e-learning and innovation, information and media technology, and life and career skills. This study aims to assess the knowledge of the application of the nine pillars of 4IR in Education among STEM teachers in Malaysia. The nine primary pillars of 4IR that create a digital revolution in industries are autonomous robots, augmented reality (AR), system integration, additive manufacturing, cybersecurity, cloud computing, big data and analytics, the internet of things (IoT), and simulation. A quantitative study approach, through a survey questionnaire, is utilized to conduct the study. Meanwhile, a sample size of 200 secondary school STEM teachers in Malaysia had been chosen through a simple random sampling technique. Mean scores are used to assess the knowledge. The findings of the study showed that the teachers are highly knowledgeable about the application of simulation (M=4.15), augmented reality (M=4.11), and autonomous robots (M=4.06) in education. Meanwhile, the teachers have moderate knowledge in the application of cybersecurity (M=3.29), additive manufacturing (M=3.27), and the internet of things (M=3.11) in education. Finally, the teachers recorded a low level of knowledge toward the application of cloud computing (M=2.48), horizontal and vertical integration (M=2.20), as well as big data and analytics (M=2.02) in education. This study gives implications for ensuring the teachers can meet the demands of the present education system and help their learners become more proficient in learning. In conclusion, integrating 4IR technology is an important aspect that needs to be utilized in teachers' teaching practices.

Keywords: *Application of 4IR, Fourth Industrial Revolution (4IR), Malaysia, Nine Pillars of 4IR, STEM Teachers*

INTRODUCTION

Education is one of the main pillars that tremendously supports a nation's growth in various sectors. The way we learn and teach subjects has evolved and will continue to develop according to the latest concepts and theories. Most importantly, in this technology-driven world, the education system has been reshaped to produce a generation of employees and entrepreneurs who are well-versed in science, technology, engineering, and mathematics. Hence, STEM Education is a widely implemented discipline in the pedagogical sector globally. STEM stands for Science, Technology, Engineering, and Mathematics.

According to Khozali and Karpudewan (2020), the integration of the STEM framework in the classroom allows for creation of meaningful learning where students can work in teams, collaboratively explore technology, and decide to solve problems through engineering thinking. However, Subramaniam et al. (2022) mentioned that many teachers feel uncomfortable implementing the STEM framework as it is complicated to integrate. Hence, the Ministry of Higher Education (MOHE) has prepared a Strategic Plan for Higher Education aimed at enhancing Malaysia's competitiveness to a more global level in the face of the Industry 4.0 revolution through a quality education and training delivery system that is compelling, relevant, and has a high commitment to learning by integrating the nine pillars of 4IR in education. The 4IR constitutes the nine pillars: autonomous robots, augmented reality, system integration, additive manufacturing, cybersecurity, cloud computing, big data and analytics, the internet of things (IoT), and simulation (Erboz, 2017). The nine pillars of 4IR can help teachers integrate STEM teaching practices effectively (Oke & Pereira Fernandes, 2020).

Autonomous robots can adapt to teachers' roles during teaching and learning sessions by mediating between teachers and pupils (Fitria, 2013). Meanwhile, AR-based teaching and learning sessions allow teachers to explain complex theories and concepts using visual representations. As for system integration, systems can be integrated vertically or horizontally. Horizontal and Vertical Integration are an organization's linking, collaborating, and cooperating systems. Horizontal Integration refers to the networking of every device and design with the same level of operational goals. Vertical Integration, on the other hand, connects the logical layers within an organization, such as production, research, development, quality assurance, information technology, sales, marketing, and human resources (Fitria, 2013). Next, additive manufacturing is the process of fabricating 3D objects, in which 3D printing is used in education to create 3D models of elements present in a lesson or to complete manufacturing-related projects. Cybersecurity, on the other hand, is the safeguarding of valuable resources generated and stored by digital instruments. It is a significant part of 4IR because it protects computer systems, networks, and data against hostile activities such as network attacks, unauthorized access, theft, interruption, and damage states (Fitria, 2013). In the context of education, cybersecurity acts as a shield for digitally stored private and confidential educational information from cyber threats. Meanwhile, cloud computing is storing, accessing, and modifying data in real-time from various remote computers (Erboz, 2017). In terms of pedagogy, cloud computing enables unlimited sharing of educational content among teachers and students via online educational platforms equipped with ample storage. Big data and analytics play an essential role in decoding information and data displayed by an individual, which is thought to be the greatest asset of our century (Ruiz-Palmero et al., 2020). Teachers can use big data and analytics in the classroom to collect and analyze student learning data to make better educational judgments. Internet of Things (IoT) demonstrates limitless connectivity between intelligent devices that compile, share, and monitor information and transmit valuable data to processing devices for decision making. Improving both the teaching-learning process and the facility in educational institutions is made feasible by the IoT, which allows for constant connectivity by accumulating, exchanging, and monitoring educational data among students' and teachers' personal intelligent gadgets and smart devices in the classroom (Gul et al., 2017). Finally, simulation can be defined as replicating a precise process with several complex components and mechanisms through virtual models (Fitria, 2013). In the context of education, complex processes involved in a lesson can be run as a computational model in simulation-based software.

Given the 4IR, a new form of a higher learning institution is emerging that does teach, research and service differently, such as massive open online courses (MOOCs), virtual classrooms and laboratories, virtual libraries, and virtual teachers. Teaching and learning can become more flexible now as they are accessed anywhere and anytime. Hence, it opens many opportunities for lifelong understanding and continuous self-development (Quah, 2020). Integrating the nine pillars of 4IR into teaching and learning practices enables 21st-century learning. According to research, using technology in education from preschool to higher education can provide numerous benefits to students, such as improving student motivation and involvement; reducing discipline issues and dropout rates; increasing student communication and collaboration, as well as communication and cooperation between teachers and students; create more stimulating work environments possible; increase classroom flexibility and teaching strategies, as well as foster greater independence and individualised learning (Rizk, 2020).

Teachers must have basic knowledge of the applications of these emerging technologies and techniques to instil them in the classroom and use them as teaching aid (Aziz Hussin, 2018).

Therefore, it is vital to identify the level of knowledge Malaysian school teachers possess regarding the applications of the nine pillars of 4IR. For instance, a study conducted by Oke & Fernandes (2020) examined the education sector's readiness for 4IR in Africa, where the findings indicated that the education sector in Africa is unprepared for 4IR. However, there are indications for opportunities to harness the potential of 4IR. The study's findings also show that 4IR can facilitate students' learning experience and transform the workplace. However, there is a need to assess the learning environment to understand the facilitators and barriers to 4IR diffusion. In the Malaysian context, such studies are limited (Siti Hajar Halili et al., 2021) since it is still considered at the early stages of implementation. Studies have focused on measuring STEM teaching practices among Malaysian teachers (Karpudewan et al., 2022a; Karpudewan et al., 2022b) instead of specific knowledge on each pillar of 4IR to be integrated into STEM teaching practices. As a result, there is insufficient information regarding Malaysian school teachers' knowledge of the applications of these pillars.

PROBLEM STATEMENT

Each of the nine pillars of 4IR has its own set of working principles, which can be thoroughly explored to harness their full potential in various applications. Therefore, teachers should equip themselves with fundamental knowledge about these abilities to ingrain the practices of utilizing these pillars in teaching and learning. According to Mpungose (2020), despite efforts to integrate the new 4IR curriculum in schools, insufficient knowledge harms the existing South African Curriculum and Assessment Policy Statement (CAPS) subjects. The Malaysian Education Blueprint (2013-2025) also insists that the nation's success in meeting global economic competition is parallel to its people's knowledge, skills, and competencies. Therefore, evaluating teachers' knowledge level in comprehending the applications of these pillars in education is necessary to assess their strengths and weaknesses and propose ways to optimize them. However, there is not enough information regarding the level of knowledge of Malaysian school teachers on applying the pillars of 4IR in education.

Teachers' knowledge of the pillars reflects their practical applications in teaching and learning sessions. This information on the level of knowledge can be generated through a well-developed instrument to measure the variable. The pillars of 4IR should be applied in education, especially in STEM education, since it relates to technological development, so that students can keep up with the continuously evolving industry when they start to work. Titik Rahayu et al. (2018) emphasized the quality of teachers as the main challenge in teaching and learning practices. According to the study, STEM is essential not only for processing and producing skilled human resources in education but, at the same time, can act as a catalyst for a country's economic growth and development.

Nevertheless, there are still various issues and challenges within the use and development of STEM in schools, and one of the challenges is related to teacher quality. Teachers' quality is essential to learning process and outcomes' effectiveness, achievement and excellence. A study by Binkley et al. (2012) found that teacher quality is a critical factor in improving students' 21st-century skills, including those related to the 4IR. The study suggests that effective professional development programs can help teachers develop the knowledge and skills needed to effectively teach 21st-century skills. Therefore, improving teacher quality, particularly in terms of their knowledge and training in 4IR concepts, is essential for effective implementation of the nine pillars of 4IR in education. Thus, this study mainly aims to investigate the knowledge of secondary school STEM teachers in Malaysia regarding applying the nine pillars of 4IR in education.

Research Objectives

1. To assess the level of knowledge on autonomous robots in education among secondary school STEM teachers in Malaysia.

2. To assess the level of knowledge on augmented Reality (AR) in education among secondary school STEM teachers in Malaysia.
3. To assess the level of knowledge on system integration in education among secondary school STEM teachers in Malaysia.
4. To assess the level of knowledge on addictive manufacturing in education among secondary school STEM teachers in Malaysia.
5. To assess the level of knowledge on cyber security in education among secondary school STEM teachers in Malaysia.
6. To assess the level of knowledge on cloud computing in education among secondary school STEM teachers in Malaysia.
7. To assess the level of knowledge on big data and analytics in education among secondary school STEM teachers in Malaysia.
8. To assess the level of knowledge of the Internet of Things (IoT) in education among secondary school STEM teachers in Malaysia.
9. To assess the level of knowledge on simulation in education among secondary school STEM teachers in Malaysia.

METHODOLOGY

Research Design

This study utilized a survey study through quantitative research methods and descriptive analysis. A questionnaire was used as a research instrument to collect data. A closed-ended questionnaire was used to collect quantitative data from the sample. The quantitative data was analyzed descriptively to determine the knowledge of secondary school STEM teachers in Malaysia regarding the nine pillars of 4IR in education. Quantitative research uses numerical data or data that can be converted into numbers (Apuke, 2017). By using a quantitative approach, the findings and objectives of this study will be more reliable as each analysis is based on numbers and facts.

Population and Sampling

The population for this study is the secondary school STEM teachers in Malaysia. STEM teachers in Malaysia refers to educators responsible for teaching a range of subjects within the STEM field, including biology, chemistry, physics, mathematics, and computer science. Meanwhile, a simple random sampling method from a non-probability sampling technique was used to select the sample for this study. Simple random sampling makes it easier for the researcher to choose respondents who can be accessed first to collect data. The total sample of this study is a total of 200 secondary school STEM teachers in Malaysia.

Research Instrument

This study uses a questionnaire as a measuring tool to obtain information and all the necessary data. There are two phases in developing the questionnaire. Phase One of the study is utilized to review 20 literature studies regarding teachers' knowledge of the application of IR 4.0 in education. The instrument used in the study is reviewed, rearranged, and analyzed. The data collected will then be used to develop a valid research instrument to collect relevant data for the study. Phase Two of the study was conducted to collect data on the teachers' knowledge of the application of the 9 pillars of IR 4.0 in education. There are a total of 68 measurement items included in the questionnaire, which are divided into 10 sections. A 5-point Likert scale, ranging from 'no knowledge' to 'superior knowledge,' was used. For example, if a measurement item was scored as 1, that means the respondent does not have knowledge of the item. On the other hand, if the item was scored as 5, the respondent is said to have superior knowledge of the item.

Table 1:
Breakdown of the Measurement Scale used in the Questionnaire

Score	*1*	*2*	*3*	*4*	*5*
Interpretation	*No knowledge*	*Minimal knowledge*	*Basic knowledge*	*Adequate knowledge*	*Superior knowledge*

Table 2:
Breakdown of Items in the Questionnaire

Section	No.of Items	Example of Measurement Items
Section A - Demographic Information	5 Items	Gender Age
Section B – Application of Cloud Computing in Education	8 Items	Data such as students, and teachers, personal information, and teaching and learning materials can be stored, accessed, and modified in real-time remotely through cloud computing.
Section C – Application of Internet of Things (IoT) in Education	8 Items	Teaching and teaming materials can be compiled, shared, and monitored among intelligent devices and educational software teachers use limitlessly.
Section D – Application of Additive Manufacturing in Education	5 Items	Teachers can use additive manufacturing (3D printing) in building a complex 3D structure in a particular subject to offer better visualization and understanding to the students.
Section E – Application of Augmented Reality (AR) in Education	6 Items	Augmented Reality allows students to see their surroundings through a digital layer that could include facts, objects, or even characters related to the content of the study.

Section F – Application of Big Data & Analytics in Education	7 Items	Big data and analytics provide teachers information regarding students' behavior while learning in the classroom, online, or mixed by statistically analyzing data generated such as student activity recordings in the process.
Section G – Application of Cybersecurity in Education	8 Items	Cybersecurity provides a secure and private platform for storing digital data in the educational sector.
Section H – Application of Horizontal and Vertical Integration in Education	5 Items	Teachers can ensure that students have a strong understanding of the fundamental concepts, involved in a particular discipline by teaching horizontally integrated courses that link the relatable basic knowledge from different subjects.
Section I – Application of Simulation in Education	9 Items	Simulation replicates a complex process and its mechanisms as a virtual model in teaching and learning.
Section J – Application of Autonomous Robots in Education	7 Items	Autonomous robots can carry out complex tasks involved in teaching and learning sessions with minimal instructions provided by teachers

Validity and Reliability Analysis

Validity is the degree to which evidence and theory support the interpretations of the test score for the proposed use (Knekta et al., 2019). In this study, validity analysis undergoes two processes, namely content and language validity. A team of experts, consisting of five English language experts and a senior lecturer, read through the questionnaire and ensured that all the contents in the questionnaire were understandable, and the language used was correct and precise. Furthermore, three STEM field experts ensured that survey questions had content validity in the study by providing critical input to improve the items. Based on the comments from the experts, several measurement items were rearranged, and clear and simple words were used to avoid any misunderstandings on the statements. Moreover, all the misspelled words were corrected. This was done to ensure that the questionnaire developed for the research is relevant, reasonable, unambiguous, and clear so that the data collected is valid for the research.

Meanwhile, reliability refers to the degree to which a phenomenon produces stable and consistent results (Taherdoost, 2016). The reliability of the variables in this study was measured using Cronbach's alpha. According to Hair et al. (2010), a research instrument is considered reliable when each variable tested with Cronbach's alpha obtains a minimum value of 0.7. A pilot test was conducted using 50 respondents to check the reliability of the research instrument. The respondents who participated in the pilot test will not be included in the final study. The findings from the reliability analysis are presented in Table 4.

Table 3:
Cronbach's Alpha Value Description

	Cronbach's Alpha	Description
I	< 0.60	Weak
2	0.60 to 0.69	Moderate
3	0.70 to 0.79	Good
4	0.80 to 0.89	Very Good
5	0.90 to 1.00	Excellent

Note: Adapted from Multivariate Data Analysis, by J.F. Hair, W.C. Black, B.J. Babin, and R.E. Anderson (2010). Pearson, New York.

Table 4:
Reliability Analysis for the Variables used in the Measurement Intrument

Variables	Number of Items	Cronbach's Alpha	Description
1. Application of Cloud Computing in Education	8 items	0.755	Good
2. Application of Internet of Things (IoT) in Education	8 items	0.752	Good
3. Application of Addictive Manufacturing in Education	5 items	0.760	Good
4. Application of Augmented Reality (AR) in Education	6 items	0.788	Good
5. Application of Big Data & Analytics in Education	7 items	0.750	Good
6. Application of Cyber Education	8 items	0.764	Good
7. Application of Horizontal and Vertical Integration in Education	5 items	0.750	Good
8. Application of Simulation in Education	9 items	0.800	Very Good
9. Application of Autonomous Robots in	7 items	0.773	Good

Table 4 shows the findings from the reliability analysis. The nine pillars of IR 4.0 were used as variables in this study. According to the results, all the measurement items used to measure each variable in the study recorded relatively high reliability. The variable of the application of simulation in education recorded very good reliability, and all other variables recorded good reliabilities. Thus, the measurement items are suitable for collecting data in the actual study.

Data Collection

This study utilized primary data collection. Primary data refers to the type of data collected directly from primary sources, such as through interviews, surveys, experiments, etc. Typically, primary data sources are selected and explicitly tailored to meet specific research objectives. Data collection was carried out through structured and closed-ended survey questionnaires to gather the required data for the study. The respondents were briefed on the research topic, its purpose, and the expected results. This was done to ensure that the respondents' rights were respected and taken care of.

Data Analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) Version 22.0 software. Descriptive statistical methods of mean score evaluation and standard deviation are used to measure the level of knowledge on the nine pillars of 4IR in education. The percentage analysis of the demographic information of the respondents is presented in Table 6 in the findings section. Additionally, the mean score analysis for the level of knowledge regarding the application of the 9 pillars of 4IR in education is shown in Table 7 in the findings section as well. The interpretation of the mean score value refers to Landell (1977), as shown in Table 5 below:

Table 5:
Mean Score Interpretation

Mean Score	Level
3.68 – 5.00	High
2.34 – 3.67	Moderate
1.00 – 2.33	Low

Source: Adapted from Management by Menu (p432), by Landell (1977). London: Wiley and Sons.

FINDINGS

Demographic Information of the Respondents

Table 6: *Percentage Analysis for the Demographic Information of the Respondents*

	Demographic Profile	Frequency	Percentage
Gender	Male	92	46.00%
	Female	108	54.00%
Age	25 years old and below	3	1.50%
	26-30 years old	25	12.50 %
	31-35 years old	40	20.00%

	36-40 years old	36	18.00%
	41-45 years old	48	24.00%
	46-50 years old	32	16.00%
	51 years old and above	16	8.00%
Educational Level	Bachelor’s Degree	118	59.00%
	Masters’s Degree	82	41.00%
Yearsof Experience	Less than 1 year	14	7.00%
	1-5 years	35	17.50%
	6-10 years	40	20.00%
	11-15 years	35	17.50%
	16-20 years	30	15.00%
	21-25 years	24	12.00%
	26-30 years	18	9.00%
	31 years and above	4	2.00%
Often implement any of the 4IR pillars in the lesson plan	Yes	120	60%
	No	80	40%

Based on Table 6, a total of 200 STEM secondary school teachers in Malaysia participated in the study. As shown in Table 5, their demographic data is collected, and the majority of the respondents are female teachers, who accounted for 54.00%. In comparison, male teachers only accounted for 46.00% of the total respondents.

Besides that, the majority of the respondents who participated in the study were those in the age group between 41-45 years old, who accounted for 24.00%. This was followed by 20.00% of respondents who were in between 31-35 years old, 18.00% of whom were in between 36-40 years old, and 16.00% of whom were 46-50 years old. On the other hand, the least number of respondents who participated in the study were teachers who were 25 years old and below, accounting for only 1.50%. Additionally, there were only 8.00% of respondents who were 51 years old and above, as well as 12.50% of respondents who were between 26-30 years old.

In terms of the highest academic qualification category, the majority of the respondents have bachelor's degrees, accounting for 59.00% of the total respondents. Additionally, 41.00% of the respondents have a master's degree.

Next, the majority of teachers who participated in the study had 6-10 years of teaching experience, accounting for 20.00% of the total respondents. This statistic is followed by 17.50% of respondents with 1-5 years of teaching experience and 11-15 years of experience, respectively. Meanwhile, 15.00%

of the respondents have 16-20 years of experience. The least respondents who participated in the study were teachers with 31 years and above of teaching experience, accounting for only 2.00%. There were also 7.00% of respondents with less than 1 year of teaching experience and 9.00% with 26-30 years of teaching experience.

The teachers were asked whether they often implement any of the 4IR pillars in their lesson plans. Positively, most of them often implement at least one of the 4IR pillars in their lesson plans, accounting for 60.00%. Meanwhile, another 40.00% of respondents agreed that they do not often implement any of the 4IR pillars in their lesson plans.

The Level of Knowledge Regarding the Application Of 9 Pillars Of 4IR In Education

Table 7: *Mean Score Analysis for the Level of Knowledge Regarding the Application of the 9 Pillars of 41R in education*

Knowledge about the Pillars of 4IR in education	Mean Score	Level of Knowledge
Application of Cloud Computing in Education	2.48	Low Level
Application of Internet of Things (IoT) in Education	3.11	Moderate Level
Application of Additive Manufacturing in Education	3.27	Moderate Level
Application of Augmented Reality (AR) in Education	4.11	High Level
Application of Big Data and Analysis in Education	2.02	Low Level
Application of Cyber Security in Education	3.29	Moderate Level
Application of Horizontal and Vertical Integration in Education	2.20	Low Level
Application of Simulation in Education	4.15	High Level
Application of Autonomous Robots in Education	4.06	High Level

Table 7 presents the mean score analysis used to determine the level of knowledge regarding the application of the nine pillars of 4IR in education. The study findings revealed that the teachers had a high level of knowledge about the application of simulation (M=4.15), augmented reality (M=4.11), and autonomous robots (M=4.06) in education. In contrast, the teachers' knowledge was moderate in the application of cyber security (M=3.29), additive manufacturing (M=3.27), and the internet of things (M=3.11) in education. Lastly, the teachers demonstrated a low level of knowledge regarding the application of cloud computing (M=2.48), horizontal and vertical integration (M=2.20), as well as big data and analytics (M=2.02) in education.

DISCUSSION

The findings showed that STEM teachers have a high level of knowledge when it comes to applying simulation in education. Simulation can be used to replicate complex processes and mechanisms into a virtual model, which can enhance students' understanding of a lesson. Teachers who are highly knowledgeable about simulation can create interactive teaching and learning environments, reduce idle time, speed up the teaching and learning process, enable repetitive learning, and conserve resources. Additionally, simulation can be especially helpful when experiments that need to be carried out by students are hazardous or expensive. According to Kincaid et al. (2003), with the help of simulation-based learning, teachers can explain complicated interconnections that would otherwise require the acquisition of expensive equipment or the conduct of hazardous experiments. For example, simulation can teach mathematics, science, and technical skills in a hands-on, integrated manner.

The teachers were highly knowledgeable about the application of AR in education, as it can be used to create immersive and enjoyable learning experiences for students. According to a review, using AR in the classroom has improved student engagement and encouraged interaction (Quintero et al., 2019). AR allows students to see their surroundings through a digital layer that can include facts, objects, or even characters related to the context of the study. Additionally, AR-based games can be utilized to make lesson plans more interactive and attract active student engagement. The study found that the teachers had fully embraced the awareness of what AR could do in education, helping to make the teaching and learning process more effective.

Besides, the teachers also have excellent knowledge of the application of autonomous robots in education. They are aware that autonomous robots can be effective teaching aids and carry out complex teaching and learning tasks with minimal teacher instructions. An effective learning environment can be created by replacing abstract concepts with physical demonstrations through autonomous robots and actively guiding the students with educational activities by giving relevant instructions without teachers having to repeat them. Additionally, the teachers are entirely knowledgeable about the perceptual capabilities of autonomous robots, which can replace manual examination methods by acting as automated marking tools. Mitnik et al. (2008) discussed how the Autonomous Educational Mobile Robot Mediator (AEMRM), being an educational tool, can physically demonstrate textbook concepts to students relevant to real scenarios and mentor educational activities while creating a stimulating learning environment. Autonomous robots with perceptual abilities may be able to develop their positions as independent tutors (Mubin et al., 2013). Specifically, in Mathematics, the drawing of two-dimensional geometric primitives and advanced complex shapes using the iRobot Create has improved students' grasp of coordinate systems (Nugent et al., 2009; Karim et al., 2015).

The teachers were found to have moderate knowledge of IoT. When shifting from manual teaching and learning to digital learning, knowledge of IoT is crucial since it is the most basic among the basics. IoT devices provide students with better access to everything from learning materials to communication channels and opportunities for teachers to track student progress in real-time. Furthermore, teachers can track and monitor their classes' attendance systems easily. In class supervision, teachers may use IoT to consider students' preferences for the subjects learned and their preferred learning approaches, creating an intelligent classroom environment. An innovative classroom attendance system saves teachers perfect time and effort due to manual processes. For instance, the Smart Classroom Roll Caller System (SCRCS) is implemented in every university classroom and reads each student's ID card, in turn, to show the total amount of actual attendance on the SCRCS LED display at the start of each class. It also allows all ID cards to be visible on the various slots of the SCRCS to prevent the student agent's actions (Chang, 2011). An ordinary classroom can be turned into a smart classroom that constantly listens and analyses words, interactions, actions, and other factors to conclude the lecturers' performance and happiness using IoT technologies and social and behavioural research (Gligorić et al., 2012).

The teachers were also moderately knowledgeable about the application of additive manufacturing in education. They know that additive manufacturing (3D printing) can be used to build complex 3D structures in a particular subject to offer better visualization and understanding to the students. An engaging learning environment can also be created through additive manufacturing-based education by assigning students projects based on 3D printing to provide them with hands-on experience, as the process involves designing a prototype, analyzing the design, operating the 3D printer, and more. The application of additive manufacturing can enhance students' problem-solving skills and creativity. Renner & Griesbeck (2020) mentioned that a fast-paced teaching and learning process is achievable by including 3D printing because it can rapidly convert an idea into a strategy. In education, 3D printing entails removing objects from computer displays and placing them in the hands of students for inspection and practical experience (Waseem et al., 2016), which creates an engaging and exciting learning session. For example, Makino et al. (2018) considered 3D printing to be remarkably appropriate for STEM education and assigned high school students to 3D print a police whistle and conduct sound frequency research as part of STEM education.

Next, the teachers have moderate knowledge of cybersecurity. A vast amount of data is generated in the education sector, including personal and sensitive information of students and teachers, classroom information, documents on assessment content, and more. Cyber threats such as ransomware, data breaches, and IoT vulnerabilities are some of the risks that teachers face, putting their confidential information at risk. For instance, hackers may obtain soft copies of exam questions stored on teachers' computers before the assessment due to inadequate password management. Therefore, preventive measures and defence technologies are required to counteract the harmful impacts of such occurrences (Erboz, 2017). Cybersecurity measures that should be used during IT applications in educational institutions include data encryption, password management, automatic data backup, and physical and virtual safeguarding mechanisms. This knowledge should be the least that teachers should possess if they start to shift into digital teaching and learning.

However, it was found that the teachers had insufficient knowledge of vertical and horizontal integration in education. This indicates that the teachers are unaware of the advantages of technology in enhancing teaching and learning. Vertical alignment harnesses the power of a team of teachers to set long-term goals for instruction and create a plan for meeting these goals. Vertical alignment teams may consist of teachers from the same school or district who teach the same subject in two or more successive grade levels. Educators who use vertical alignment to support cohesive instruction will find it helps them save instructional time by reducing repetition. Meanwhile, horizontally integrated teaching improves cognitive and psychomotor domains. Implementing integrated education in the medical curriculum through official policy in consultation with faculty would be beneficial to ensure better results.

Next, the study recorded that the teachers had insufficient knowledge of applying big data and analytics in education. The use of Big Data and Analytics in the field of pedagogy brings a new way to explore the real-time effects of existing educational practices. Traditional approaches for determining students' learning ability and constructing preferred course structures can be time-consuming and complex. Technological breakthroughs like this can assess the pattern of failure and success in achieving learning outcomes and provide individualized learning approaches for optimum performance. Consequently, teachers may now access their students' academic achievement and learning patterns and provide immediate feedback thanks to the introduction of Big Data (Black & Wiliam, 2018). Furthermore, by employing Big Data techniques, plagiarism, considered a widespread unethical activity among students, can be efficiently addressed. Due to the abundance and ease of access to written material on the internet, manual detection of plagiarized work may be futile. Big Data, in this case, serving as the foundation for anti-plagiarism, functions to cross-check information between new and current papers in search of any correlations (Ruiz-Palmero et al., 2020). Hence, it appears that the teachers have not yet stepped up their knowledge ahead of the students to track any misconduct from them.

Regrettably, the teachers have a low level of knowledge of the application of cloud computing in education. This means that the teachers need to get out of their comfort zone and learn more about cloud computing. This is because, as the teaching and learning process massively shifts into digital learning or e-learning, it is relevant for the teachers to know the application of cloud computing in education so that it helps them greatly aid the teaching and learning process to become smoother. Cloud computing allows teachers to store and monitor the students' academic and personal data remotely from anywhere using any of their devices connected to the internet. Furthermore, teachers can establish a more collaborative workforce by sharing simple teaching materials to acquire and implement. On top of that, a private cloud system can be installed at a reasonable cost, ensuring the privacy and security of the data stored (Sultan, 2010).

CONCLUSION

As the educational sector is continuously evolving and developing following technological development and innovation, the teachers must have basic knowledge of the applications of these emerging technologies and techniques to instil them in the classroom. This is important so that they can prepare the students with the most advanced knowledge to keep up with the technological development and their relevance as teachers in this century. This study can be the pioneer in assessing the teachers' understanding of all the nine pillars of 4IR and their application in education through a valid and reliable research instrument in Malaysia. However, this study is limited to representing STEM secondary schools only. At the same time, the knowledge of other teachers in different categories such as arts and literature towards applying the nine pillars of 4IR in education remains unknown. Further study in the future can be done by investigating the acceptance and practices of the teachers towards the application of 4IR pillars so that a more profound understanding can be achieved on the knowledge of the applications of the nine pillars of 4IR in education.

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