DEVELOPING AN INSTRUMENT TO MEASURE STEM TEACHERS' KNOWLEDGE ON THE APPLICATIONS OF THE 9 PILLARS OF 4IR AND MEASURING THE MODERATING EFFECT OF KNOWLEDGE ON THE RELATIONSHIP BETWEEN SELF-EFFICACY AND STEM TEACHING PRACTICES

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by

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LIST OF ABBREVIATIONS

3D	Three-Dimensional
4IR	Fourth Industrial Revolution
AEMRM	Autonomous Educational Mobile Robot Mediator
AR	Augmented Reality
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CMAR	Concept-Mapped Augmented Reality
CV	Curriculum Vitae
EBD	Educational Big Data
EFA	Exploratory Factor Analysis
HTMT	Heterotrait-monotrait ratio
IaaS	Infrastructure as a Service
IoS	Internet of Services
IoT	Internet of Things
KMO	Kaiser-Meyer-Olkin
M-21CSI	Malaysian 21st Century Skills Instrument
PaaS	Platform as a Service
PCK	Pedagogical Content Knowledge
PLS-SEM	Partial Least Squares Structural Equation Modeling
RMSEA	Root Mean Square Error of Approximation
SaaS	Software as a Service
SCRCS	Smart Classroom Roll Caller System
SCs	Cyber-Physical Systems
SEM	Structural Equation Modelling
STEBI	Science Teaching Efficacy Believe Scale

STEM	Science, Technology, Engineering, and Mathematics
STEMTIP	STEM Teachers' Instructional Preparedness Instrument
UTAUT	Unified Theory of Acceptance and Use of Technology
WEF	World Economic Forum

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MEMBANGUNKAN INSTRUMEN UNTUK MENGUKUR PENGETAHUAN GURU STEM MENGENAI APLIKASI 9 PILAR 4IR DAN MENGUKUR KESAN MODERATOR PENGETAHUAN TERHADAP HUBUNGAN ANTARA EFIKASI DIRI DAN AMALAN PENGAJARAN STEM

ABSTRAK

Kajian ini bertujuan untuk membangunkan dan menilai alat bagi mengukur pengetahuan guru STEM (Sains, Teknologi, Kejuruteraan, dan Matematik) mengenai aplikasi 9 Pilar Revolusi Industri Keempat (4IR), serta menyiasat impak pengetahuan ini terhadap hubungan di antara keyakinan kendiri guru dan amalan pengajaran STEM. Penyelidikan melibatkan pembangunan alat kajian serta pengumpulan data melalui tinjauan dalam kalangan guru STEM untuk meneroka hubungan antara pengetahuan 4IR, keyakinan kendiri, dan pelaksanaan strategi pengajaran STEM yang berkesan. Hasil kajian dijangka memberikan pandangan berharga tentang kaitan penting antara kesedaran guru terhadap kemajuan 4IR, keyakinan dalam kemahiran pengajaran, dan integrasi amalan pengajaran STEM yang inovatif. Implikasi kajian ini berkaitan dengan dasar pendidikan dan program pembangunan profesional untuk meningkatkan kualiti pendidikan STEM dengan menyelaraskan persediaan guru dengan tuntutan transformasi Revolusi Industri Keempat.

DEVELOPING AN INSTRUMENT TO MEASURE STEM TEACHERS' KNOWLEDGE ON THE APPLICATIONS OF THE 9 PILLARS OF 4IR AND MEASURING THE MODERATING EFFECT OF KNOWLEDGE ON THE RELATIONSHIP BETWEEN SELF-EFFICACY AND STEM TEACHING PRACTICES

ABSTRACT

This study aims to develop and assess an instrument for measuring stem (science, technology, engineering, and mathematics) teachers' knowledge of the applications of the 9 pillars of the fourth industrial revolution (4IR) and to investigate the impact of this knowledge on the relationship between teachers' self-efficacy and stem teaching practices. The research involves the development of a valid instrument and data collection through a survey administered to STEM teachers, exploring correlations between 4ir knowledge, self-efficacy beliefs, and the implementation of effective stem teaching strategies. The study's findings are expected to provide valuable insights into the crucial connection between educators' awareness of 4ir advancements, their confidence in teaching skills, and the practical integration of innovative stem teaching practices. Implications include informing educational policies and professional development programs to enhance stem education by aligning teacher preparation with the transformative demands of the fourth industrial revolution.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The current state of science and technology has significantly altered and triggered new trends in our way of life. The Fourth Industrial Revolution (4IR) is one of these trends that has gotten a lot of attention in the last decade because of its potential to drastically overhaul how economic and social institutions operate. Philbeck and Davis (2018) have described 4IR as an "epi-digital" revolution, in which new technologies become more interwoven into the physical, social, and political worlds, causing fundamental transformations in human behavior, relationships, and the way people perceive things (including products and services). As we walk through the history of human civilization, water, and steam power were used to mechanize production during the First Industrial Revolution spanning the years 1760-1840. The Second which began in the late 19^{th} century and continued until the early 20th century made mass production possible by utilizing electric power. Electronics and information technologies were employed to automate production in the third which began in the 1960s. A Fourth Industrial Revolution is now taking shape, building on the third, the digital revolution that began in the middle of the past century (Schwab, 2017).

The nine primary pillars of 4IR that create a digital revolution in industries are autonomous robots, augmented reality (AR), system integration, additive manufacturing, cyber security, cloud computing, big data and analytics, internet of things (IoT), and simulation. First, autonomous robots handle complicated issues that humans can't overcome. Second is augmented reality (AR), which can add a digital layer to our existing environment. Third, horizontal and vertical integration (system integration) can integrate cyber-physical systems (SCs) in a factory. Fourth, additive manufacturing consists of the usage of 3D printing technology. Fifth, cyber security plays a role as a barrier to cyber threats. Sixth, cloud computing creates a shared platform that serves multiple users. Seventh, big data and analytics harvests and analyses large, complex sets of data that affect decision-making. Eight, the internet of things (IoT) builds connections of physical objects and systems. Last but not least, simulation provides mathematical models and algorithms for existing processes. (Erboz, 2017a)

The emergence of these pillars in the pedagogical sphere paves the way for the 21st-century classroom. Twenty-first-century classroom equips the new generation of learners with 21st-century competencies to face future challenges. According to, (Osman et al., 2010) The Malaysian 21st Century Skills Instrument (M-21CSI) consists of five distinctive elements which are: (i) Digital Age Literacy;(ii) Inventive Thinking; (iii) Effective Communication; (iv) High Productivity, and (iv) Spiritual Value. In tandem with these elements, STEM Education (Science, Technology, Engineering, and Mathematics) is an interdisciplinary subject that teaches students how to integrate and apply these four fields in the current world (STEM Implementation Guide in Teaching and Learning, 2016). Furthermore, the Design and Technology subject also focuses on basic practical skills, design skills, and entrepreneurship practice, as well as the ability to apply technology basics to produce critical, creative, and inventive students (Curriculum and Assessment Standards Document, Design and Technology, Year Five, 2014). As a result, understanding the 9 pillars of 4IR is critical for teachers who teach the subject as it can be used to mediate teaching and learning sessions.

The methods that scientists and engineers use to understand the natural world and find solutions to issues are referred to as STEM practices. These problem-solving abilities are important for both teaching and learning (Yilmaz & Ayaz, 2021). In fact, the majority of definitions of inquiry refer to scientific practise or method, and these pedagogies are associated with fruitful educational outcomes. All STEM areas and jobs place a high priority on scientific practises, despite the fact that these abilities are frequently covered by discussions of critical thinking or problem-solving techniques. Examples of these techniques include speculating and forecasting, providing explanations or making claims based on facts, planning and conducting experiments, and creating and utilising models (Yilmaz & Ayaz, 2021).

Teaching STEM techniques in non-lab courses, particularly to large student populations, presents a number of difficulties. One worry is that the teachers are unable to cover as much material as they otherwise because they are concentrating on the science method (Margot & Kettler, 2019). However, when there is extensive treatment of numerous different topics, it is important to take into account how thoroughly students are able to absorb content. Real science and engineering also require applying content using the scientific method. Students can build a deep understanding of both material and process in a way that is more applicable to how science and engineering are done by having them wrestle with the most fundamental, core ideas in a topic through application via STEM practises (Kelley & Knowles, 2016).

The degree of authenticity attached to a task that a teacher gives students is another difficulty in instructional strategies. Spending too much time on relatively straightforward and unauthentic uses of reasoning abilities may not be productive, even though it would be challenging to maintain the degree of authenticity of how science is conducted in research and other STEM fields. Opportunities for students to exercise some discretion in how they interact with content in general are also advantageous (Kelley & Knowles, 2016). It should be a goal of approaches to teaching STEM practises to give students the opportunity to integrate their reasoning abilities through iteration and prompt feedback directed at the practises' more difficult components.

STEM methods are also ideal for providing students with timely, detailed feedback that is unrelated to results or getting the right answer on tasks and assignments (Kelley & Knowles, 2016). Students are less inclined to take intellectual risks in courses whose tests and evaluations solely value accurate responses. If teachers place a high emphasis on the ability to think critically and apply scientific principles but do not provide feedback or evaluate such abilities, students will probably fall back on finding the easiest way to succeed in the class. Teachers should make explicit expectations for students, provide opportunities for iteration and feedback over right answers, and reward student cognitive risk-taking through assessment (including low-stakes assessments) of these skills in order to design curriculum activities that draw on and enhance students' critical thinking (Annetta et al., 2014).

Teaching STEM techniques in non-lab courses presents a number of difficulties, particularly in big lecture settings. One issue is that instructors may not be able to cover as much material as they otherwise could because they are concentrating on the science method. However, when there is extensive treatment of numerous different topics, it is important to take into account how thoroughly students are able to absorb content. Real science and engineering also require applying content using the scientific method. Students can build a deep understanding of both material and process in a way that is more applicable to how science and engineering are done by having them wrestle with the most fundamental, core ideas in a topic through application via STEM practices (Kennedy & Odell, 2014).

Teachers must have sufficient knowledge of the 9 pillars' functioning principles to use them as a teaching and learning aid especially for successful STEM practices. In becoming 21st-century instructors and to meet the learning preferences of Gen Z students, teachers must relearn and equip themselves with digital tools Aziz Hussin, 2018). Consequently, the acquired knowledge of teachers on the working principles of the 4IR pillars should be evaluated through a valid instrument. This is because, to be competitive, the changes brought about by the Industry 4.0 phenomenon necessitate a highly knowledgeable and skilled human resource (Junida et al., 2019).

It's futile to have comprehensive knowledge and skills on the 9 pillars of 4IR if teachers are unwilling to put them into practice in the classroom. Accordingly, another aspect of 21st century learning to consider is teachers' self-efficacy. Dellinger et al., 2008) endorse this by stating that while engaging in environmental situations, self-efficacy beliefs are theorized to moderate relationships between knowledge and practice. In the context of teachers, Saienko et al. (2020) define pedagogical self-efficacy as a belief, which is represented in the teachers' confidence in their professional competence, the ability to carry out the instructional activity by adopting relevant resources, as for this study the 9 pillars of 4IR, which will result in the attainment of the educational process results.

1.2 Background of Study

The German government was the first to develop 4IR to modernize industrial manufacturing through digitization and the use of new technology (Erboz, 2017; Rojko, 2017). The national 4IR policy states that 4IR involves the transformation of industries via emerging technology. A study regarding a conceptual framework to support digital transformation in manufacturing using an integrated business process management approach (Butt, 2020) describes the latest production processes due to digitalization of manufacturing industries are through the 9 pillars of 4IR and their design principles. The six main design principles of these 9 4IR pillars are interoperability, virtualization, decentralization, real-time capability, service orientation, and modularity. Interoperability enables cyber-physical systems, humans, and factories to effectively connect and communicate with one another via IoT and the internet of services (IoS). Virtualization creates a virtual copy of the factory by integrating sensor data, virtual plant models, and simulation models. The ability of cyber-physical systems in factories to make optimal decisions on their own is referred to as decentralization. Real-time capability is critical because it allows for the collection, analysis, and generation of insights in real-time. Aside from that, to fulfill the service-orientation principle, it must provide services of cyber-physical systems, humans, and factories via the IoS. It is flexible in adapting smart factories to changing requirements of individual modules due to the modularity principle. Understanding the design principles from a pedagogical approach provides teachers with insights into the 9 pillars' functionality and how to apply them during teaching and learning sessions.

First and foremost, Teachers have a variety of obligations in the field of education, including planning and carrying out educational activities, supervising students, evaluating them, and so on. Hence, their tedious tasks are greatly reduced when autonomous robots are included in the educational system, and students benefit from an interactive and effective learning approach. In particular, Mitnik et al. (2008) discusses how the Autonomous Educational Mobile Robot Mediator (AEMRM) being an educational tool can be used to physically demonstrate textbook concepts to students that are relevant to the real scenarios and to mentor educational activities while creating a stimulating learning environment. Autonomous robots with perceptive abilities may be able to develop their positions as autonomous 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 interoperability principle between autonomous robots, teachers, and students is best seen here have one line linking with STEM education.

As for Augmented Reality (AR), since abstract concepts can be demonstrated by visual examples, incorporating this technology into the teaching-learning process can be game-changing. Teachers may use AR resources to create immersive and enjoyable learning sessions for their students. According to a review, using AR in the classroom has improved student engagement and encouraging interaction (Quintero et al., 2019). Chen et al. (2016) developed a Concept-Mapped Augmented Reality (CMAR) learning system to assist science students in exploring and understanding the fundamentals of the food chain, and determined that it had a good impact on their learning motivation.- AR tools may also be used to assess students without the need for teachers to prepare test questions ahead of time. Teachers can save a lot of time with real-time testing and input so they can quickly analyze the outcomes and understand the students' academic achievement through AR-based educational apps

From a pedagogical standpoint, system integration in the teaching and learning process, which is supported by the curricular system, allows lessons to be connected horizontally and vertically to improve learning outcomes. A horizontally integrated curricular model links several courses with basic knowledge within a discipline, mostly simultaneous and usually within a single academic year. As for a vertically integrated curricular model, basic courses within different academic years are being linked with advanced practical courses such as clinical (Rodríguez-Martín et al., 2019).

Apart from that, material extrusion, commonly known as 3D printing a form of Additive Manufacturing, is becoming increasingly popular in educational institutions due to significant cost savings and widespread commercial availability. A fast phase teaching and learning process is achievable by including 3D printing because it can rapidly convert an idea into a process (Renner & Griesbeck, 2020). Furthermore, the digitalization of models through this method of additive manufacturing enables teachers to simplify the teaching of complex theories and concepts as well. 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. As an example, Makino et al. (2018) considering 3D printing to be greatly appropriate for STEM education, assigned high school students to 3D print a police whistle and conduct sound frequency researchers as STEM education.

Cyber-security is an important technology in the educational sector as well. A vast quantity of data is generated in the educational sector, including personal and sensitive data of students and teachers, classroom information, documents on assessment content, and the like. Ransomware, data breaches, and IoT vulnerabilities are cyber threats teachers face, putting their confidential information at risk. For example, hackers may be able to acquire soft copies of exam questions stored on teachers' computers before the assessment due to inadequate password management. Therefore, to counteract the harmful impacts of terror occurrences, preventative measures and defense technologies are required (Erboz, 2017a). Cybersecurity measures that should be used during IT applications at educational institutions include data encryption, password management, automatic data backup, and physical and virtual safeguarding mechanisms.

Moreover, Cloud-Computing is another exceptional feature that can be applied in pedagogical practices). Teachers can benefit from SaaS and PaaS if the scope is limited to pedagogical advancements. IaaS allows a complete computer infrastructure that consists of virtual computers, servers, storage devices, etc to be delivered remotely through the internet. PaaS, on the other hand, allows for remote application management without the need for local hardware, operating systems, databases, middleware, web servers, or other software (Sultan, 2010). As a result, teachers can store and monitor their pupils' academic and personal data remotely from anywhere using any of their devices connected to the internet. The ability to remotely administer educational software has increased the flexibility of the teaching and learning process through fast data sharing, particularly during pandemics. Furthermore, teachers can establish a more collaborative workforce by sharing teaching materials that are simple to acquire and implement. On top of that, a private cloud system can be established at a reasonable cost, ensuring the privacy and security of the data stored.

The use of Big Data and Analytics in the field of pedagogy brings up 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, on the other hand, 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, learning patterns, and provide immediate feedback thanks to the introduction of Big Data (Black & Wiliam, 2018). Furthermore, employing Big Data techniques, plagiarism, which is considered a widespread kind of unethical activity among students, can be efficiently addressed. Because of the abundance and ease of access to written material on the internet, manual detection of plagiarised 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).

Furthermore, The use of IoT in academia is like a fresh generation of transformation that has opened up new avenues and possibilities for improving both the teaching-learning process and the facilities of educational institutions (Gul et al., 2017). The Internet of Things in the classroom means a more connected and collaborative future for education. IoT devices also provide students with better access to everything from learning materials to communication channels, as well as the opportunity for teachers to track student progress in real-time. Furthermore, teachers can now track and monitor their classes and attendance systems with ease thanks to the IoT. In terms of class supervision, teachers may use IoT to consider students' preferences for the subjects learned and the learning approaches they prefer which creates a smart classroom environment. Due to manual processes, including a smart attendance system in classrooms saves perfect time and effort for teachers. For instance, the Smart Classroom Roll Caller System (SCRCS) is a system that 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). Additionally, IoT tools can provide real-time feedback on the consistency of the learning process. An ordinary classroom can be turned into a smart classroom that constantly listens and analyses words, interactions, actions, actions, and other factors to conclude the lecturers' performance and listeners' happiness using IoT technologies and social and behavioural research (Gligorić et al., 2012).

In the context of education, the most challenging task of a teacher is to present a topic and ensure that the students grasp the concepts. The complexity of a study, as well as the constraints of materials and equipment necessary to support it, has always been a bottleneck. With the intervention of simulation-based learning, teachers can explain complicated interconnections that would otherwise either the acquisition of expensive equipment or the conduct of hazardous experiments. For instance, math, science, and technical skills can all be taught in a hands-on, integrated manner using simulation (Kincaid et al., 2003). Real-time data collected throughout the teaching and learning process using Big Data and Analytics can also be utilized to test and analyze the effectiveness of the sessions. As a result, teachers may gain insights into how to approach a given subject. To support this, Erboz (2017a) states simulation models, which allow dynamic analysis of production processes using real-time data, could be used for strategic planning.

Integration of the 9 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 collaboration between teachers and students; create more stimulating work environments possible; Increase classroom flexibility and teaching strategies, as well as foster greater independence and individualized learning (Rizk, 2020). Teachers must have basic knowledge in the applications of these emerging technologies and techniques to instil them in the classroom.

Therefore, it is vital to identify the level of Malaysian school teachers regarding their knowledge on the applications of the 9 pillars of 4IR. For instance, in Africa (Oke & Fernandes, 2020) conducted a study to examine the education sector's readiness for 4IR using the Unified Theory of Acceptance and Use of Technology (UTAUT).In the Malaysian context, such studies are limited and are from predatory sources. As a result, there is no sufficient information regarding the knowledge of Malaysian school teachers' knowledge on the applications of these pillars. Due to this scenario, the development of a valid instrument to gauge this variable is necessary.

Self-efficacy of teachers is arguably important as it is instrumental for teachers in deciding to include these pillars in teaching and learning sessions. Teachers with high self-efficacy are always prepared with a broad variety of knowledge, not just in terms of curriculum and pedagogy, but also in terms of how to apply information technology to meet current demands(Ismail et al., 2020). To identify the self-efficacy of teachers the Science Teaching Efficacy Believe Scale (STEBI) can be used as a measurement tool to gain a better understanding of teacher behavior, which can aid in the creation of initiatives for teacher preparation and in-service to improve primary science instruction(Rigg & Enochs, 1990).In this study, STEBI is further modified to the context of self-efficacy of teachers in applying the pillars of 4IR in education.

1.3 Problem Statement

Each of the 4th Industrial Revolution's 9 pillars has its own set of working principles, which can be used to harness their full potential in a variety of applications if thoroughly explored. On that account, teachers should equip themselves with fundamental knowledge about their abilities in ingraining the practices of utilizing these pillars in teaching and learning. According to, Mpungose (2020) despite efforts to integrate a 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 triumph of our nation in meeting global economic competition is parallel to the knowledge, skills, and competencies of its people. 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. However, there is not enough information regarding the level of knowledge of Malaysian school teachers on the application of the pillars of 4IR in education.

Teachers' knowledge of the pillars reflects their effective 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. Existing studies focus on the development of instruments on Pedagogical Content Knowledge (PCK) to measure teachers' content knowledge on Environmental Education

(Abdullah & Halim, 2010). Besides that, Ramli et al. (2020) conducted a study on the development and validation of the STEM Teachers' Instructional Preparedness Instrument (STEMTIP) to measure teachers' instructional preparedness. Nevertheless, there are limited valid instruments to measure teachers' knowledge on the applications of the 9 pillars of 4IR in education.

Bandura (1997) states that perceived self-efficacy relates to people's belief in their abilities to achieve specific goals. A plethora of studies on teachers' self-efficacy about different factors has been conducted. A study conducted 33by Alibakhshi et al. (2020) concluded that teachers' self-efficacy has positive consequences for teachers' instructional behaviors and strategies: pedagogical/instructional support, classroom management, and emotional support. Another study argues that having a deep understanding of a subject does not always protect teachers from having doubts about their capacity to perform effectively in the classroom (McCampbell, 2015; Zee & Kooomen, 2016). Thus, the self-efficacy of teachers in practicing 4IR tools-based teaching and learning is equally important. As Khanshan and Yousefi (2020) believes that teacher effectiveness is a multifaceted construct that varies depending on tasks and situations, it should be investigated in a variety of settings with teachers from various backgrounds. Exploring the differences between disciplines other than those investigated in this study will also provide insights into teacher efficacy studies. Therefore, more studies should be conducted to measure and establish a relationship between teachers' self-efficacy and the knowledge of the applications of the 4IR pillars in teaching and learning sessions.

1.4 Research Objectives

This study aims to identify the level of teachers' knowledge on the applications of 4IR tools in the classroom through a well-developed instrument to measure their knowledge in this area and to establish a relationship between the self-efficacy and application of the pillars. Therefore, the objectives of the research are as follows:

i) To explore the literature on teachers' knowledge on the applications of the 9 pillars of 4IR in education to develop a valid instrument.

ii) To determine the key items that measure STEM teachers' knowledge of 4IR through Exploratory Factor Analysis (EFA)

iii) To confirm the validity of the items extracted from EFA using Confirmatory Factor Analysis (CFA).

iv) To determine whether knowledge moderates the relationship between teachers' self- efficacy and the applications of 4IR pillars in education.

1.5 Research Questions

This study is carried out to identify the level of knowledge of applying 4IR tools in the classroom among Malaysian school teachers and the relationship between their self-efficacy and the practice of implementing these tools in the classroom. Specifically, it attempts to answer the following questions:

i) What are the items that measures teachers' knowledge on the application of the 9 pillars of 4IR in education ?

ii) What are the factors structured of the knowledge of teachers on the applications of the 9 pillars of 4IR in education extracted from Exploratory Factor Analysis (EFA)?

iii) What are the factors structured of the knowledge of teachers on the applications of the 9 pillars of 4IR in education confirmed using Confirmatory Factor Analysis (CFA)?

iv) Does knowledge significantly moderate the relationships between teachers' self-efficacy and the practice of implementing the pillars of 4IR in education?

1.6 Hypothesis

Based on the aforementioned research questions, the following hypothesis is formed:

H1: Knowledge significantly moderates the relationships between teachers' self-efficacy and the practice of implementing the pillars of 4IR l in education.

1.7 Significance of the study

This study proposed a model that investigated the level of Malaysian school teachers' level of knowledge on the applications of 4IR through a valid instrument. It aims to enhance teachers' understanding regarding the importance of the applications of 4IR tools through evaluating their level of knowledge in this area. By evaluating teachers can learn and adapt the techniques of implementing 4IR tools in teaching and learning sessions. Furthermore, the study has also identified that there are insufficient valid instruments to measure Malaysian school teachers' knowledge of the applications of 4IR tools in the classroom. The development of a valid instrument to overcome this issue will provide better insights for policymakers on teachers' level of knowledge and carry out drastic measures to improve it. Besides that, understanding the relationship between Malaysian school teachers' knowledge, self-efficacy, and the practice of implementing 4IR for teaching and learning enables policymakers to come up with strategies to create awareness regarding the importance of 4IR tools-based education among teachers. This is because, teachers' cognitive(knowledge) and affective (personal beliefs) elements affect their instructional practice (Depaepe & König, 2018).

The development of the questionnaire to measure teachers' knowledge of the application of 4IR in education has significant implications for various stakeholders, including teachers, students, the Ministry of Education, policymakers, and curriculum developers. For teachers, the questionnaire will help them identify areas where they need further training and professional development (Tavares & Costa, 2021). For students, the questionnaire findings will inform the development of 4IR-focused curriculum and teaching practices, which will better prepare them for the future job market (Karim & Hamdan, 2021; UNESCO, 2019). The results of the questionnaire will also guide policy decisions aimed at improving education outcomes by providing a clearer picture of the current state of 4IR knowledge among teachers (OECD, 2019). Finally, for curriculum developers, the questionnaire will help identify areas where 4IR concepts are not adequately integrated into the curriculum, allowing for the development of curricula that incorporate 4IR concepts more effectively (World Economic Forum, 2020). Overall, the questionnaire has the potential to bring about positive changes in the education system, better preparing students for the future and improving education outcomes.

1.8 Scope and Limitations of Study

The study aims to understand the level of teachers' knowledge on the applications of 4IR tools in the classroom through a valid instrument and their self-efficacy to implement these tools. The World Economic Forum (WEF) has listed complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation, and cognitive flexibility as the top 10 skills for teachers in becoming 21st-century instructors. In this study, narrowed down the level of knowledge teachers acquires on the applications of 4IR tools in teaching and learning sessions.

The first limitation was the location of the study's respondents. Teachers in Malaysia were the only ones who responded. Apart from that, the bulk of teachers that took part in the first phase of the study was from the state of Perak. As a result, only teachers in this situation may have issues in applying the pillars of 4IR in education. The level of knowledge identified through the instrument could have been focused and revolving around teachers in schools from Perak and may be different for teachers from other states. This could affect the development of an instrument which later might affect the development of a standardized instrument for all the teachers in Malaysia.

1.9 Operational Definition

1.9.1 The 9 Pillars of 4IR

The 4IR constitutes the 9 pillars: autonomous robots, augmented reality, system integration, additive manufacturing, cyber-security, cloud computing, big data and analytics, internet of things (IoT), and simulation (Erboz, 2017). Teachers' knowledge of 4IR comprises teachers' understanding of the pillars and application of the pillars in the educational context.

While defining autonomous robots we have to understand that, robots were developed with the intent of allowing machines to perform complex and repetitive tasks with no or minimal human intervention provided with instructions. These robots have evolved to perform a diverse range of services through adaptive, cooperative, and autonomous operations (Fitria, 2013). This research focuses on autonomous robots' ability to adapt to teachers' roles during teaching and learning sessions by acting as a mediator between teachers and pupils.

Augmented Reality (AR) is described as the addition of a digital layer that can consist of a collection of facts, objects, or even characters in our actual space. AR is a technology that integrated three-dimensional (3D) virtual objects into a 3D real-world environment in real-time (Billinghurst et al., 2014). In terms of pedagogy, AR-based teaching and learning sessions allow teachers to explain complex theories and concepts by using visual representations.

As for system integration, systems can be integrated vertically or horizontally. Horizontal and Vertical integration is the linking, collaborating, and co-operating of systems in an organization. Horizontal integration refers to the networking of every device and system of the same level of operational goals. Vertical Integration on the other hand connects the logical layers within an organization such as production, research, and development, quality assurance, information technology, sales and marketing, human resources, etc (Fitria, 2013). From the educational context, it refers to the integration of different levels of curriculum based on the content (horizontal) and content-based real-world circumstances in teaching and learning sessions.

Additive manufacturing, Additive manufacturing is the process of fabricating 3D objects by layering materials such as polymers, ceramics, or metals. Binder jetting, Directed Energy Deposition, Powder Bed Fusion, Sheet Lamination, Material Extrusion, Material Jetting, and Vat Photo Polymerization are the 7 types of additive manufacturing processes. 3D printing is a sort of additive manufacturing used in education to create 3D models of elements present in a lesson or to complete manufacturing-related projects.

Cyber security, on the other hand, is the safeguarding of valuable resources generated and stored by digital instruments is what cybersecurity is all about. It is a significant part of Industry 4.0 because it protects computer systems, networks, and data against hostile activities such as network attacks, unauthorized access, data theft, interruption, and damage states (Fitria, 2013) In the educational context, cyber-security acts as a shield for digitally stored private and confidential educational information from cyber-threats.

Cloud computing is defined as the process of storing, accessing, and modifying data in real-time from various remote computers. Erboz (2017a) describes it as a method of virtualizing resources and services, as well as merging client/server systems. Cloud computing has the potential to revolutionize management and administration in the educational field. Studies have identified the realms of cloud computing as, Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (Erboz, 2017a). In terms of pedagogy, cloud computing enables unlimited sharing of educational content among teachers and students via online educational platforms equipped with large storage.

Big data and analytics play an important 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) states that the study and interpretation of the huge amounts of data produced can help with decision-making and the execution of recommendations that can improve reality. Big Data and Analytics can fully exploit the value of this knowledge by extensively evaluating it and forecasting probable consequences. From an educational perspective, 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 smart devices which compiles, shares, and monitors any kind of information and transmits the useful data to processing devices for decision making. The use of IoT in academia is like a fresh generation of transformation that has opened up new avenues and possibilities for improving both the teaching-learning process and the facilities of educational institutions (Gul et al., 2017). This is made feasible by the Internet of Things, which allows for endless connectivity by accumulating, exchanging, and monitoring educational data among students' and teachers' personal smart gadgets and smart devices in the classroom.

Simulation can be defined as replicating a precise process with several complex components and mechanisms through virtual models explains simulation significantly. (Fitria, 2013) express those simulations were used to test system designs to see if they met specific predetermined goals. In the context of education, complex processes involved in a lesson can be run as a computational model in simulation-based software.

In the context of research, an instrument is a tool used for gathering, measuring, and analysing data about your topic. Tests, surveys, scales, questionnaires, and even checklists can be used as research instruments. In this study, proposed a valid instrument in the form of questionnaires to measure the knowledge of teachers in utilizing 4IR tools for teaching and learning. The questionnaire measures teachers' knowledge using 5 points Likert scale that measures the 9 pillars of 4IR.

1.9.2 Self-Efficacy of Teachers

According to Bandura (1977), the certainty of teachers on their ability to deal with tasks, responsibilities, and challenges that comes with their professional field is known as self-efficacy. Rigg and Enochs (1990) states that the STEBI can be used as a measurement tool to gain a better understanding of teacher behavior, which can help with the creation of methods for teacher preparation and to improve elementary science instruction which in our study will be the implementation of 4IR tools in the classroom.

1.9.3 STEM Teaching Practices

STEM tteaching practices involve an interdisciplinary approach to learning that emphasizes problem-solving, critical thinking, and creativity. The 4th Industrial Revolution (4IR) has brought about new technologies such as artificial intelligence, robotics, and the Internet of Things, which are transforming the way we live and work. To prepare students for this new era, educators are incorporating the four pillars of 4IR, namely, digital literacy, computational thinking, problem-solving, and creativity, into their teaching practices. Research has shown that the integration of these pillars in STEM education can enhance students' learning outcomes and better prepare them for future careers in STEM fields (Duncan, 2018; Tavares & Costa, 2021).

1.10 Summary

This chapter begins with an introduction followed by a full background of the study and the problem statements. The study's purpose, as well as the research's objectives, were explained. The research questions and hypothesis were also discussed in this chapter. This is followed by a discussion of the study's significance. This chapter concluded with a discussion of the study's scope and limitations, as well as definitions for keywords used throughout the text.