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Policies and governance for skills development in the fourth industrial revolution

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ABSTRACT

The fourth industrial revolution (4IR) has intensified policy concerns regarding the capacity of technical and vocational education and training (TVET) systems to support future workforce development. While national strategies increasingly emphasize skills development for industry 4.0, less attention has been paid to the governance mechanisms that shape policy coherence and implementation. This study examines skills governance within Malaysia's TVET system, focusing on how policy alignment, quality assurance (QA), institutional coordination, and industry engagement influence workforce readiness for the 4IR. Adopting a qualitative approach, data were collected through focus group discussions (FGD) with key stakeholders from government agencies, industry, and TVET institutions, and analyzed thematically. The findings identify four key governance dimensions which are security procedures and policies in managing skills data, QA and standards, collaboration policy between institution and industry, and strengthens curriculum developments. Despite strong policy commitments, fragmented governance arrangements continue to constrain the effectiveness of skills development initiatives. By reframing skills development as a governance challenge, this study contributes to policy futures debates and offers insights for strengthening integrated and future-ready TVET governance frameworks in developing economies undergoing rapid socio technical transformation.

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1. INTRODUCTION

The transformation associated with the fourth industrial revolution (4IR) is not merely technological in nature but structural in its implications for labor markets, education systems, and national skills planning [1]. Previous study [2] discussed that unlike previous industrial transitions, 4IR accelerates the integration of digital, physical, and biological systems, demanding new forms of competencies that traditional training systems are often slow to accommodate. This situation presents a significant governance challenge, particularly for technical and vocational education and training (TVET) institutions tasked with preparing a workforce for emerging industries.

In Malaysia, the responsibility for skills formation is distributed across multiple agencies, institutions, and industry actors. While various policies have been introduced to enhance TVET relevance,

questions remain regarding how governance mechanisms translate these policies into effective skills development practices [3]. The issue is not a lack of policy attention, but rather how coordination, implementation, and monitoring occur across institutional levels.

The development of an effective TVET system is at the heart of education reform efforts. These systems can be very complex and have many different faces and often the prime responsibility of Ministries of Education or Ministries of Human Resources. For governments and policymakers, it is vital that the enabling mechanisms are put in place for the 4IR to be a sustainable revolution [4]. The governance challenge is even greater than in previous industrial revolutions due to the complexity, pace, and global and sectoral breadth of change [5]. Zero-cost digital distribution today enables products and services to penetrate the mainstream and 'go global' in a matter of months, with policy and regulation often struggling to keep up [6].

For the 4IR to be the first sustainable industrial revolution, governments and regulators will need to adapt quickly with the rapidly evolving landscape and provide the enabling environment, safeguards, investment and oversight to guide the future that is being built. Support and partnerships will be needed to unlock and scale innovation on emerging and potentially game-changing technologies and solutions for people and the world. Foresight, public policies and technological governance will be needed to avoid or minimize unintended consequences for skills development [7].

The 2030 agenda for sustainable development aims to integrate and indivisible and balance the three dimensions of sustainable development which are the economic, social, and environmental [8]. The sustainable development goals (SDGs) are a set of 17 global goals adopted by all United Nations Member States in 2015 as part of the 2030 agenda for sustainable development. These goals are aimed at addressing various global challenges, including poverty, inequality, climate change, environmental degradation, and more. The SDGs provide a comprehensive framework for achieving sustainable development worldwide [9]. The success of these goals depends to a large extent on the coordination of implementation efforts through good public governance.

The SDGs along with the role of governance and the skills required from the 4IR, are interconnected in the pursuit of sustainable development. The skills associated with 4IR technologies enable innovation, efficiency, and data-driven decision-making in various sectors [10]. For instance, AI and data analytics can be used to optimize resource management, while blockchain can enhance transparency in supply chains. Digital literacy and 4IR skills are essential for harnessing these technologies to address SDG challenges effectively. While the SDGs hold great potential, their collective success will depend on a few numbers of institutional factors such as the extent to which states formalize their commitments, improve associated global governance structures, translate global goals into national settings, integrate sectoral policies, and keep governance mechanisms flexible [9].

Research communities may also play a significant role in monitoring true progress, matching objectives with current governing frameworks, and integrating economic, social, and environmental factors [11]. The International Labour Organization (ILO) 2008 declaration on social justice for a fair globalization stressed the importance of governance as a foundation for making the aim of productive employment and decent work for all a primary goal of state policies. Along with "employment, social protection, and labor rights," "social dialogue" remains one of the ILO's four strategic objectives [12]. In order to prepare high-level skilled labor in the national labor market, the government determines that TVET should be strengthened and dignified [13]. As Malaysia moves toward developed nation status, it needs world-class skilled talent through TVET, as current skills lag behind technological advances amid the 4IR. The technologies that surround us will alter all aspects of life and the skill sets required in both old, new occupations will change in most industries and transform how and where people work. It may also affect female and male workers differently and transform the dynamics of the industry's gender gap [3].

This industrial 4.0 phenomenon can be seen in terms of education and job skills in the industry. It is necessary to foster self-potential to provide an exciting opportunity to transform society for the better [14]. Cyprus Pedagogical Institute [15] also mentioned that it is crucial to understand the global community as well as meet the needs of the 21st century job market which includes the ability to think critically, take initiative, use digital tools, solve problems and work together in a group. The 4IR integrates physical, digital, and biological technologies, creating major impacts and sustaining strong demand for skilled technical workers despite educated youth unemployment [16]. This shows that the need to embrace skill sets for the industrial revolution must start from now. This research develops policies and governance to align TVET with future industry needs and build a resilient, future-ready workforce.

Despite the proliferation of national strategies addressing industry 4.0 and workforce transformation, skills development policies often remain institutionally fragmented and unevenly governed [17]. In Malaysia and elsewhere, TVET responsibilities are spread across multiple agencies, causing overlap, inconsistent quality assurance (QA), weak industry alignment, and challenges to policy coherence and long-term sustainability amid rapid change [18]. These governance challenges raise critical questions about policy

coherence, accountability, and the long-term sustainability of skills development systems in the face of rapid socio-technical change. While existing studies on TVET and industry 4.0 largely focus on curriculum reform, digital skills, and pedagogical innovation, fewer studies critically examine how governance structures and policy coordination shape the effectiveness of skills development initiatives. Addressing this gap, the present study explores skills governance as a central policy issue, offering future-oriented insights into how TVET systems can be better aligned with emerging workforce demands.

According to the 11th Malaysia Plan 2016–2020, 60% of employment would require TVET skills which is TVET will undoubtedly be the most significant means of expanding the supply of human capital capabilities for the country's economic development. As a result, the government has strategically focused its planning efforts on generating high-quality TVET graduates, as outlined in the Malaysia Education Blueprint 2015–2025 [19]. The nation's social, economic, political, competitive, and long-term growth heavily relies on its people's capabilities and quality, as well as its educational systems, which range from early childhood to lifelong learning. Among the numerous policies and governance associated efforts in higher education over the last decade, the global framing of national credentials has been viewed as a critical and significant endeavor in enhancing learning, skills, and competences in support of national policy and governance development goals [20]. Malaysian TVET education and training places a strong focus on industry practices, to produce industry-relevant, competent workers to support the country's socioeconomic goals. Knowledge and cognitive skills, functional and job skills, and specialized learning goals are the general learning outcomes clusters that apply to all TVET qualifications.

The Ministry of Higher Education (MOHE) through Malaysian Qualifications Agency (MQA) accountable for strengthening the TVET sector so that it can compete with the academic sector. Skills and vocational sectors have been combined into one TVET sector as part of the Malaysian qualification framework (MQF) review. As a result, the MQF solely includes academic and TVET sectors. For all industries' qualification descriptions, the MQF defines the same abilities and learning goals [21]. The difference will be in how the programmed are delivered. Rapid advancements and developments in TVET have resulted in a wide range of delivery methods and QA procedures for TVET providers' programs. As a result, standardization of TVET QA which involves of policies and governance systems is both required and opportune in Malaysia.

2. METHOD

2.1. Research design

A qualitative research design within a focus group discussion (FGD) is used in the data collection procedures for this study. The FGD entails small groups of participants contributing to moderate group discussions on a certain topic [22]. This method is an economical, fast, and efficient method for obtaining data from multiple participants [23]. In this study, the focus groups assisted in identifying the most relevant issues to be discussed during the discussion session. FGD is a valuable qualitative research method for observing and understanding the depth and breadth of opinions, experiences, and attitudes related to a specific topic. The richness of the insights gained from focus groups can complement the received data and provide a holistic view of the subject matter. Thematic analysis (TA) is an accessible, flexible, and increasingly popular method of qualitative data analysis and provides a systematic and structured approach to analyzing qualitative data. Researchers follow a clear set of steps, including data familiarization, coding, theme identification, and interpretation, which helps ensure rigor and consistency in the analysis process [24].

2.1.1. Expert participants/panels

A total of 20 participants were involved in the discussions, representing TVET institutions, industry sectors, and regulatory stakeholders associated with national skills development. Participants were selected based on their direct involvement in training implementation, standards development, QA processes, and industry collaboration initiatives. This purposive selection ensured that the discussion captured perspectives from individuals who actively engage with governance mechanisms in their professional roles. The diversity of participants allowed the study to examine governance issues across institutional, regulatory, and industry dimensions within the TVET landscape.

2.1.2. Data collection procedure

The focus group sessions were conducted in a structured yet flexible manner, guided by semi-structured questions designed to prompt discussion around governance practices, institutional collaboration, quality standards, and curriculum responsiveness. Each session encouraged participants to elaborate on real experiences rather than theoretical perspectives. The discussions were recorded and transcribed to preserve the authenticity of participants' views. Field notes were also documented to capture non-verbal cues, group dynamics, and contextual elements that enriched the interpretation of the data.

2.1.3. Interview protocol

The discussion protocol was developed to explore four main aspects: governance coordination, QA practices, institutional–industry collaboration, and curriculum development for emerging skills. Questions were designed to encourage participants to reflect on how policies are implemented, how standards are maintained, and how institutions adapt to technological changes. This approach ensured that the data collected remained closely aligned with the study's objective of understanding governance in action rather than governance in theory. The data from focus group session was collected using recording audio and were transcribed and analyzed using TA to identify the theme and code aided by data analysis software, ATLAS.ti.

2.2. Data analysis procedure

In this study, researchers used theme analysis method to analyze the collected interview data. Theme analysis is one of the methods of identifying, analyzing and reporting patterns (themes) in qualitative data [25]. Data were examined alongside multiple sources to derive categories and themes, with ATLAS.ti used to organize data and generate thematic codes The theme table is not determined from the beginning of the study, however, the data analysis process started from open coding to get as many themes and categories to be associated with the study phenomenon, followed by axial coding and selective coding. Therefore, managing and categorizing the data is the most important component throughout the study from the beginning to the conclusion stage of the study findings [24]. This analysis minimally organizes and describes the set data in detail. This study refers to the findings and emergence of themes derived from the interview results. Theme determination can also be determined using ATLAS.ti software. The implementation of qualitative analysis requires a large amount of carefully and complex managed text, code, memos, and notes [26].

3. RESULTS

In this study, the researcher used TA method to analyze the collected interview data. Theme analysis is one method of identifying, analyzing and reporting patterns (themes) in qualitative data [24]. The results from the FGD have shown that four strategic aspects need to be considered by the Department of Skills Development (DSD) in strengthening and fostering human potential for skills development in 4IR which are security procedures and policies in managing skills data, QA and standards, collaboration policy between institution and industry, and strengthens curriculum developments.

3.1. Security procedures and policies in managing skills data

Three aspects that emerged from the discussion involving security procedures and policies in managing skills data, which are data analysis skills competency, re-skilling and up-skilling employee's technology data skills, and supporting security system to support the technology. Data analysis skills competency is one of the important aspects mentioned by the panels. Comments made by the panels were all about how they need introduce one technology based on the technology's influence on current human capital and productivity, rather than merely the technology itself, as mentioned by the panel P5:

> "*I think we have to go back, there are new skills. But if you ask me, in term of training, you can't have one program that caters to overall industry 4.0. If you are in wood industry, you have to find add on that required for our wood industry, yes some of competent skills. It can be also, the data analysis skill that embedded in that program.*"

Re-skilling and up-skilling employee's technology data skills is another important aspect in nowadays industries. In the case of some organizations, re-skilling and up-skilling employees are necessary because currently, the industry is getting more competitive. Therefore, we must improve productivity and data-related technological skills, and upgrade technology by all means. We have to look at how to develop our trainer, so the training programs should be progressively strong as well to keep in line with 4IR in order to produce quality students. Supporting security systems to support the technology aspect is not less important from the other two. It is stated clearly in which said by the panel P4 as:

> "*We are not technology creator or inter-venter all this while we are user. We buy technology to develop, we use it but we don't have supporting to support technology that we buy for Malaysia.*"

This shows that we clearly need to either have our own supporting technology or create our own to uphold and sustain the existing system. We could see how developed countries keep being excited to design and shape brand-new supporting technologies to encourage their country, not only in the economic aspect, but also for people to keep up with the environment. As a developing country, we need to catch up to create our own supporting technologies so they can suit our country's environment.

3.2. Quality assurance and standards

The QA and standards can be divided into two major aspects, which are the penetration of international standards and regulatory policy trends. The term regulatory policy refers to a system of rules, processes, and policies set by Government-created entities or any organization whose sole duty is to establish. Policy and regulatory trends that promote sustainability must be well disseminated and channeled; this can be taken up by special training administrators, and review regulations panel P7 once said:

> "*We have the policy and regulatory trends that promote sustainability. But the question is, how much people know about it and how we have to disseminate the information to public.*"

Another aspect that was highlighted in the discussion is to penetrate international standards.

> "*For oil and gas industry, yes, we can develop NOSS, we can encourage them to have SKM but then our industry looking for international certification. It is good if industry we can develop SKM with collaboration in international certification.*"

3.3. Collaboration policy between institution and industry

The next aspect that was being pulled up by the panelist during the discussion is collaboration policy between institution and industry. Three aspects have emerged from this discussion which are collaboration between institution and industry, lifelong learning in skills development and digitalization of TVET. The first aspect that emerge is collaboration between institution and industry. Collaboration with all the stakeholders involved such as universities, human resources and skills trainers, government and private sectors will facilitate the formation of knowledge with the support of experts and experienced persons in the industry that can give a right direction to the enthusiastic, intelligent students and making them experts of future. As panelist P1 said:

> "*… We have establish our academic, collaborate with the university as well as HR and JPK. We also go with NOSS. In term of training of coz not every training program we can conduct thru the trainer that we have, of coz on and off we also engage with government agencies and private sectors …*"

Not being left out in the discussion is another element which lifelong learning in skills development. In this era of globalization, we have to furnish and provide our students and workers with channels to learn skills to continuously learn as part of the culture of lifelong learning because it is difficult to predict what kind of skills are required for the 4IR and enable them to adapt and adopt the new technology. The motivation and encouragement on what to learn and how to learn should be emphasized and this starts in the educational institution itself. Panelist P6 said that,

> "*… One thing about industry 4.0 something that very difficult to predict what are the skill requirement. That skills set they will be needed. What happen is we need to furnish our student and workers with the skills to continuously learnt, continuously learning skills. That means having the motivation to learn and also knowing how to learnt …*"

As the world goes on, everything has been digitalized and not being able to communicate through the digitalized environment is a big no. The world keeps evolving and demanding us to follow its path. To be compatible to communicate through digitalized world is a must, so that we can keep moving forward, together with the industrial revolution that we face right now. The last aspect that being discuss is the digitalization of TVET. A panel, P6 said that:

> "*… But the more digitalization and industrial revolution will happen, the more the skills on jobs, let say. Professions become more academic like you said, ICT and so on. and this is also a chance to raise maybe the image of TVET through digitalization and industry 4.0 …*"

The digital workforce has developed many competencies during their interactions with technology that may be leveraged at work and also encourage workers to master the latest technologies or digital competencies in order to keep in a competitive position in various industries.

3.4. Strengthens curriculum developments

The result of discussion this theme has three aspects, which are, implement learning management system, information and communication technology (ICT) teaching and learning policy, and curriculum empowerment to enhance technical and soft skills. The next aspect that was discussed by the panelist is

implement learning management system to deliver knowledge for all generation. Experience is what differentiate the current personnel with the new and old generations. Delivering knowledge is very crucial to make sure the experience in terms of knowledge will last. A panelist, P17 said:

> "*They invest to the industry, but when we talk about industry revolution, we can say it very difficult to industry to implement and execute it because involve money, policy, incentive so I will suggest to JPK we should have one road map how to implement for the time being it is the stage of planning look at the stage of implementing monitoring for 4IR because not everybody know about it.*"

Digital skills to deliver knowledge can be said as the ability to use digital devices, communication applications, and networks to access and manage information to be hand over to the old and newcomers. As we know, the new generations mostly depending on digital devices to make things happen and in getting new information, but not for the old generation. That makes the skill of using digital skill to deliver knowledge is so crucial right now. We might say that the digital communication is currently the best business to invest on. The first important point that came up during the discussion was ICT teaching and learning policy. There are a lot of online platforms that provide training courses, either the free courses or otherwise. Panel P3 said that:

> "*…. And as of today, a lot of the training also offered through online courses if they want to upgrade themselves. They sign up with course to get the certificate, we see more and more that kind of training...*"

An online course is the delivery of a series of lessons on a web browser or mobile device, which can be accessed anytime and at any place. So, there is a need a certain policy and governance to control it. It is designed as an online environment for convenient learning asynchronously. Those courses might offer certificate such as participation certificate, and also competency certificate. This will increase the individual skills and if chances are taken seriously, there are a lot to learn in online platforms. The last aspect of this discussion is curriculum empowerment to enhance technical and soft skills. One comment made by the panel, P12 is that:

> "*To me, the things must be exist together. Not to say merge and one merges without both. Actually, both are important. Because in our educational system itself, it almost 70% are not interested in academic. They are more towards skills, you know. The excellent people only 30% who are moving toward academics. But, the rest, where are they? In the vocational, this is what TVET all about.*"
> "*In our passion to supply technical skills that can meet the challenges of industry 4.0, we shouldn't be forgetting about our basic skills. Humanizing skills, humanizing aspect of our workers.*"

There is now more pressure on academic institutions to enhance both technical skills and soft skills of their students. Thus, the learning institution needs to look at back to the policies, syllabus, the process and the methodology on how to bring their students moving forward in the forthcoming revolution. Also, the institution needs to provide a clear career path or framework guidance for students to make sure they get the clear direction after graduated. With well-planned training programs, it is possible to tune, shape and develop creativity and all skills needed among all students. This is important to make sure the produce of skilled workers with a combination of technical skills and soft skills as a need to fulfil 4IR.

Figure 1 conceptualizes skills development for the 4IR as a governance driven ecosystem within Malaysia's TVET system. The framework identifies four interrelated strategic dimensions: security procedures and policies in managing skills data, quality assurance and standards, collaboration policy between institution and industry, and strengthening curriculum development. The first dimension highlights digital governance capacity, including data competency, reskilling initiatives, and technological support systems necessary for institutional resilience. The second underscores regulatory coherence, standardization, and alignment with international benchmarks to ensure qualification credibility. The third emphasizes structured industry–institution collaboration, lifelong learning, and digitalization to enhance labor market responsiveness. The fourth links governance to pedagogical execution through ICT policies, learning management systems, and balanced integration of technical and soft skills. Collectively, the model demonstrates that workforce readiness for 4IR depends not merely on curriculum reform, but on coherent, coordinated, and adaptive governance mechanisms that enable sustainable and future-ready TVET transformation.

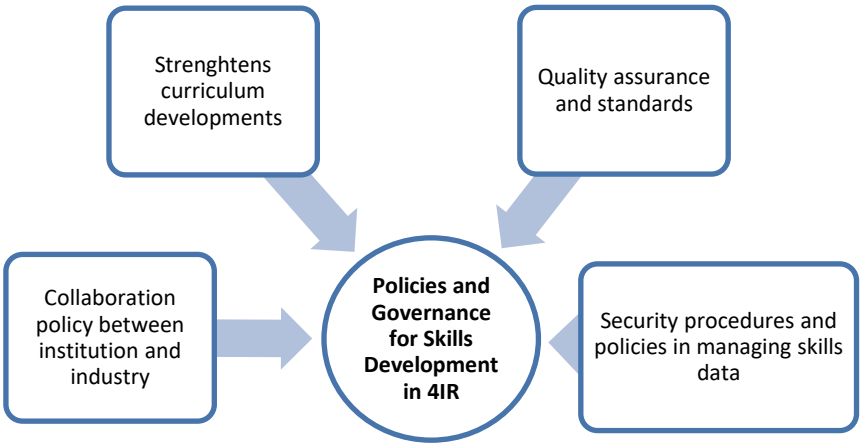

Figure 1. Four strategic aspects in policies and governance for skills development in 4IR

4. DISCUSSION

This study sets out to examine skills development for the 4IR through the lens of policy and governance rather than solely through curriculum or training provision. The findings reveal four interrelated governance dimensions that shape the effectiveness of Malaysia's TVET system in preparing a future-ready workforce: security procedures and policies in managing skills data, QA and standards, collaboration policy between institution and industry, and strengthens curriculum developments. First, the findings related to security procedures and policies in managing skills data highlight the growing importance of digital governance within TVET systems. Rather than reflecting isolated technical concerns, issues related to data analysis competency, reskilling, and technological support point to broader governance challenges surrounding data stewardship, institutional capacity, and system resilience. In the absence of coherent digital governance frameworks, investments in advanced technologies risk reinforcing skills gaps rather than mitigating them. From a policy futures perspective, strengthening digital governance is essential to ensure that skills systems remain adaptive as technologies continue to evolve.

Today's era is a fully digital era in every sector, hence there is a need to move parallel and being proficient in using high technology to deliver, communicate to each role player and vice versa [27]. Globalization and the intensive use of information and communication of high technology have led to the emergence of a new economy [28] which is a knowledge and idea-based economy where the keys to job creation and higher standards of living are innovative ideas and technology embedded in services and manufactured products. This was also supported by previous study which have found that employees who understand and can leverage the power high technology will also be valuable to organizations [29].

The role of the employees together with the role of technology can lead to advanced learning results [30]. Taken together, these findings suggested that the DSD can create self-development programs and enhance talent for employees such as re-skilling, up-skilling and upscaling. Also, policy should be implemented to prepare the aging society to face and contribute towards 4IR as the younger ones would be ready to accept 4IR demands in the future. The older group should be able to contribute economically to Malaysia and government should gear towards the innovation and well-being of 4IR and not leaving behind senior citizens. The need for sharing knowledge between research institutions and industry has become increasingly evident in recent years [31]. So, DSD are suggested to organize any programs that can improve industrial experience of using high technology among workers [32].

The research clearly indicates the needs of QA and standards from two aspects of discussion, which are to penetrate international standards and regulatory policy trends. The findings indicate that while policy frameworks and regulatory instruments exist, their impact is often constrained by limited dissemination, uneven implementation, and weak alignment with global certification standards. This reflects a broader governance issue in which regulatory mechanisms struggle to balance flexibility with standardization. Without integrated QA governance, TVET systems risk producing qualifications that lack credibility, portability, and long-term relevance in an increasingly globalized labor market. The 2008 financial and economic crisis underscored the significance of a well-functioning regulatory framework for transparent and efficient markets with the correct incentives [33]. Besides that, the DSD and institutions are suggested to provide comprehensive ecosystem to workers or graduates to adopt communication skill, digital literacy skill, practical skill and cognitive skill in learning outcome domains. Also, national occupational skills standard (NOSS) should develop an international certification for SKM who are interested in becoming entrepreneurs,

provide infrastructure, collaboration with training institutions and international organizations and encourage more innovations to be generated [34].

The discussion revealed upon collaboration policy between institution and industry consists of three aspects which are collaboration between institution and industry, lifelong learning in skills development and digitalization of TVET. Effective collaboration extends beyond ad hoc partnerships or memoranda of understanding; it requires institutionalized mechanisms that support shared decision-making, mutual accountability, and sustained engagement. Lifelong learning and the digitalization of TVET further reinforce the need for governance models that facilitate continuous skills upgrading across the lifespan. From a future-oriented policy standpoint, fragmented collaboration arrangements limit the capacity of TVET systems to anticipate and respond proactively to emerging industry demands. Malaysia can benefit from partnership between academics and industry in creating new skills for 4IR [35]. These collaborations also allow the university to organize memorandum of understanding (MOU) agreements to ensure that students are in line with industry needs and to extend the on-the-job training (OJT) period so that students may learn about the industry environment.

The digital skills agenda is in rage, and much is being done to encourage young people to realize the importance of this skill in 4IR. The arrival of computing on the curriculum shows that the importance of digital skills is being recognized [36]. Due to the world challenge nowadays and COVID-19 pandemic, there is a need for people to empower their digital skills to make challenge and obstacle faced to become a great opportunity [37]. Thus, DSD are suggested to implement digital literacy enhancement courses such as coding for instructors and students. Furthermore, DSD can also try to implement cyber security surveillance, security assurance, cyber forensics, cryptographic technologies, and security management based on NOSS requirement. Institutions should promote online learning to strengthen students' digital and technical skills, while also developing communication, critical thinking, collaboration, creativity, problem-solving, and social values to keep them competitive.

Results from the study have also shown that strengthens curriculum developments has three aspects, which are having balance in technical and soft skills, enhance soft skills to deliver technical skills and curriculum empowerment to enhance technical and soft skills. In this new era, most of the employers need their employees to not only possess technical or hard skills but also generic skills or soft skills to face the new world challenge to sustain and competitive [38]. The findings suggest that balancing technical skills with soft skills, supported by appropriate teaching and learning policies, is essential for workforce adaptability in the 4IR era. Curriculum reform alone is not enough without governance that aligns policy, institutions, and labor market needs; future curriculum governance must be flexible, inclusive, and aligned with changing careers.

Employees that possess soft skills will be able to adapt to any working situation and versatile (multi-skilled) suitable with the needs of the current job market [39]. Technical knowledge and skills alone have a short life span and job specific, thus may not be transferable to other trades. Each employee must have the desire to upgrade his or her skills (for example) if he or she is to continue contributing to the progress of the organization [38]. When there was an economic crisis quite recently, many workers lost their jobs entirely through voluntary retirement or forced retirement. The employer retains some, and they however, are required to undergo a retraining to learn new skills and acquire new knowledge. To make today's students and industrial users familiar with the topic and the related challenges, new curricula are necessary [40]. These findings point to broader governance challenges that constrain the adaptive capacity of TVET systems in responding to industry 4.0 transformations. Develop and implement government policies in education and training to meet the 4IR demand. Re-plan policies to ensure marketability. Taken together, these findings suggest that skills development for the 4IR should be reconceptualized as a governance challenge rather than a purely educational or technological one. Although this study is situated within the Malaysian context, the governance issues identified policy fragmentation, regulatory misalignment, and coordination gaps are characteristic of many developing economies navigating rapid socio-technical transitions. The study enhances discussions on future policy by emphasizing the necessity for cohesive and proactive governance structures that establish TVET as a fundamental component of sustainable workforce development.

5. CONCLUSION

This study reconceptualizes skills development for the 4IR as fundamentally a governance challenge rather than a purely curricular, pedagogical, or technological issue. Drawing on qualitative insights from multi-stakeholder discussions within Malaysia's TVET ecosystem, the findings demonstrate that persistent fragmentation in policy coordination, regulatory practices, institutional collaboration, and curriculum responsiveness constrains the capacity of TVET systems to effectively respond to rapid socio-technical change. Four interrelated governance dimensions emerged as critical levers for future-ready skills systems:

security procedures and policies in managing skills data, QA and standards, collaboration policy between institution and industry, and strengthens curriculum developments. These dimensions collectively illustrate that workforce preparedness for the 4IR depends not only on what is taught, but on how policies are coordinated, how standards are aligned, how institutions collaborate, and how governance mechanisms enable continuous adaptation.

The study contributes to policy futures scholarship by demonstrating that effective TVET transformation requires integrated governance frameworks capable of bridging institutional silos, aligning national qualifications with international standards, embedding digital stewardship within skills systems, and institutionalizing industry engagement beyond ad hoc partnerships. In this regard, governance coherence emerges as a precondition for curriculum relevance, QA credibility, and sustainable skills development. Good governance involves transparent and accountable decision-making, strong institutions, inclusive policies, and active engagement with stakeholders. It requires collaboration between governments, civil society, businesses, and international organizations to mobilize resources and drive sustainable development efforts. Policies and governance is crucial for coordinating efforts across sectors, regions, and stakeholders to achieve these goals. Future research should move beyond identifying governance dimensions to examining implementation mechanisms, institutional capacities, and evaluative frameworks that translate governance principles into operational practice. Strengthening the evidence base on how governance reforms influence skills outcomes will be essential for advancing both scholarly understanding and policy effectiveness in the era of the 4IR.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
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R : **R**esources
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O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

To ensure fair and objective decision-making, authors declare that no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

INFORMED CONSENT

The protection of privacy is a legal right that must not be breached without individual informed consent. We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author [NAJ]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

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