

# Institutional Response to Implement 4IR Competencies into Programme Offerings of Technical and Vocational Education and Training in Indo-Pacific

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DOI: <https://doi.org/10.30880/jtet.2024.16.03.012>

## Article Info

Received: 9th September 2024  
Accepted: 12th November 2024  
Available online: 23rd December 2024

## Keywords

Competencies, training, higher education, IR4.0, TVET

## Abstract

The paper provides results of a study that investigated the response of technical and vocational education and training (TVET) institutions for the implementation of 4<sup>th</sup> industrial revolution (4IR) competencies into programme offerings. The investigation was confined to TVET in science, technology, engineering, and mathematics (STEM) fields at the tertiary level. 470 TVET staff responded to the survey from 15 countries, all of which belonging to the middle-income category in Indo-Pacific. The study examined institutional response covering eight areas, i.e., financial support for digital transformations, support for partnerships, job market sensitivity, support for changes to programme offerings, popularization of programme offerings, support for teacher development, support for adherence to quality, and the overall assessment of institution management in response to implementing 4IR competencies into programme offerings. The results showed significant differences in the institutional response for the eight areas by the institution type - TVET regulatory bodies, TVET teacher training and research institutes, TVET universities, polytechnics, and TVET colleges.

## 1. Introduction

The target of technical and vocational education and training (TVET) is to prepare youth and adults for the world of work with a lifelong learning framework by offering flexible learning options throughout a person's life cycle. Within a particular county context, the TVET system can be identified as a vital contributor to resilience building due to its closeness to the labour market in producing a competent workforce to meet the priorities of continued economic and social development. Although the academically oriented traditional university education system and TVET system operate as two distinctive systems of higher education, at the micro-level of programme offering both have many similarities in terms of generic aims and approaches to teaching and learning (ILO, 2020). Still, the TVET system operates under different rules for qualifications, competencies, and accreditations, to name a few (for more ILO, 2020). When it comes to competencies, TVET at the tertiary level focuses on middle-level competency development with direct and immediate application in the industry (production or service). As a result, forward-looking countries always identify TVET and its future direction as of utmost importance in policy agendas (Schröder, 2019).

The world we live in today is volatile, uncertain, complex, and ambiguous, i.e., VUCA (Millar et al., 2018). Organizations operating in the VUCA world, including TVET institutions, cannot simply update their approaches – a shift in kind is needed by altogether replacing the existing approaches to doing things (Millar et al., 2018; Schoemaker et al., 2018). In doing so, increased reliance on digital technologies of the fourth industrial revolution (4IR), such as artificial intelligence, 3D printing, and robotics are required for survival and growth (Goger et al., 2022; Lanteri, 2021; Schwab, 2017; World Economic Forum, 2016). Therefore, the 21<sup>st</sup> century is identified as an era of intense transformation with “supercomplexity” (Barnett, 2000). According to Barnett (2000), the higher education landscape got “supercomplex” when encapsulating the development of 4IR technologies. With reference to the education sector, 4IR digital technologies enable fundamental shifts in teaching and learning or, in broad, how the education sector should function. On the one hand, three aspects are important in the implementation of 4IR competencies into programme offerings, i.e., subject content needs to cover 4IR technologies, digital skills should be acquired by the staff to use 4IR technologies, and programme offerings should be delivered using 4IR technologies. The COVID-19 pandemic and subsequent lockdowns had the initial impact of digital technology on programme delivery by moving existing classes and curricula online without proper centrally planned initiatives, coordination, or national standardization for digitalization (France et al., 2021; Goger et al., 2022; ILO, 2020; Spöttl & Windelband, 2021; TVET Academy, 2021; Veal and Dunbar, 2017; Whalley et al., 2021). Therefore, the response of higher education sector to the COVID-19 pandemic should not be misunderstood as the implementation of 4IR competencies into programme offerings. On the other hand, the personnel engaged in the delivery of programmes and the recipients, i.e., students, come from different age generations. Students enrolled on higher education programmes in the current day are mostly comprised of Generation Z (born between 1997 and 2012) and the generation alpha will follow them soon (born between 2010 and 2024). Higher education institutions should cope and strive in this multi-generational landscape. Such challenges from the current operating environment need to be perceived as opportunities for higher education institutions to transform teaching and learning approaches to move along with 4IR. This is especially vital for teaching and learning engagement with subjects involving science, technology, engineering, and mathematics (STEM). However, the literature suggests that the transformations are not happening at the pace desired in the higher education sector (Ilori & Ajagunna, 2020; Jung, 2020; Spöttl & Windelband, 2021).

When making transformations to adhere to the broader operating environment, the TVET institutions should play a pivotal role as the providers of skilled manpower in a country. At higher levels of an organizational hierarchy, with more administrative or managerial responsibilities, an individual’s or a leader’s role-related targets (or key performance indicators) get entangled with institution-level targets. In this sense, in making transformations to address 4IR requirements, at the TVET institutional level, personnel in leadership capacities should play a pivotal role (Schoemaker et al., 2018). The steps taken by TVET leaders to address 4IR requirements will be seen and understood as actions of TVET institutions. In this regard, in the context of secondary education, Ontario Principals Council (2014) states that educational institutions should be comprised of instructional leaders to make a difference to the teaching and learning. In the context of business management, Manyika et al. (2018) states that business leaders must understand the changing landscape, challenge their operating personnel, and endlessly innovate to face challenges.

The present study investigated how TVET staff engaged in STEM fields belonging to four types of TVET institutions, i.e., TVET regulatory bodies, TVET teacher training and research institutes, TVET universities, polytechnics, and TVET colleges perceived the response of their respective institutions to implement 4IR competencies into programme offerings. The study examined eight areas, i.e., financial support for digital transformations, support for partnerships, job market sensitivity, support for changes to programme offerings, popularization of programme offerings, support for teacher development, support for adherence to quality, and the overall assessment of institution management in response to implementing 4IR competencies into programme offerings. Whilst there is a widespread agreement that technological and socio-economic developments of the 4IR are making a substantial impact on the agenda of higher education, especially TVET systems, limited research attention has been paid so far to understand the response of TVET institutions for the implementation of 4IR competencies into programme offerings. Specifically, empirical studies on TVET institutions in the backdrop of 4IR are still nascent. Case-based or single country-based experiences available in the mainstream literature are insufficient for informed decision-making. For the growth of TVET systems, more broad-based empirical studies are vital. For the present study, the data were collected from 470 TVET staff engaged in STEM fields at the tertiary level from 15 countries in Indo-Pacific. Table 1 shows the countries included in the study along with a country’s regional and income classifications (The World Bank, n.d.). A detailed description of the sample is given in the section on methodology.

**Table 1** *Countries and characteristics*

Country	% from total <sup>1</sup>	Region	Income
Bangladesh	10.45	South Asia	Lower middle income
Bhutan	3.83	South Asia	Lower middle income
Cambodia	7.01	East Asia & Pacific	Lower middle income
Fiji	1.28	East Asia & Pacific	Upper middle income
India	14.47	South Asia	Lower middle income
Malaysia	6.17	East Asia & Pacific	Upper middle income
Mongolia	1.7	East Asia & Pacific	Lower middle income
Myanmar	6.17	East Asia & Pacific	Lower middle income
Nepal	4.68	South Asia	Lower middle income
Pakistan	7.01	South Asia	Lower middle income
Papua New Guinea	1.7	East Asia & Pacific	Lower middle income
Philippines	12.55	East Asia & Pacific	Lower middle income
Sri Lanka	9.15	South Asia	Lower middle income
Thailand	6.6	East Asia & Pacific	Upper middle income
Viet Nam	7.23	East Asia & Pacific	Lower middle income

Notes: <sup>1</sup> = 470 (=100%)

## 2. Technical and Vocational Education and Training in Context

The TVET system of a country is responsible for developing skilled manpower. As per UNESCO-UNEVOC International Centre for TVET (2020), “equipping all youth and adults with the relevant knowledge, skills, and competencies for work and life, and this should be done through an overall lifelong learning framework” (p. 7). In doing so, a TVET system engages in eight core functions - governance, standard development, design and development of programmes, program delivery, accreditation and quality assurance, provision of apprenticeships for trainees, and capacity building of TVET staff (The World Bank Group, 2021). The VUCA world and 4IR technologies are impacting the way all higher education institutions should function. Although TVET institutions are coping much better than other higher education institutions due to their closeness to the labour market, the literature suggests that higher education institutions, in general, are struggling to keep up with the speed of changes (Alade & Windapo, 2020; Ilori & Ajagunna, 2020; Jung, 2020; Spöttl & Windelband, 2021). Hence, higher education institutions should play an active role in driving the transformation agenda (Alade & Windapo, 2020; Gonçalves, 2019; Pima, 2019; The World Bank Group, 2021). However, the findings of previous studies suggest the existence of gaps in the perceived role of leaders in implementing 4IR competencies into TVET programme offerings (The World Bank Group, 2021; UNESCO-UNEVOC International Centre for TVET, 2020). These studies emphasise the importance of leaders being able to develop a vision for the institution, plan, communicate, and facilitate for 4IR agenda across the institution. In this regard, Alade and Windapo (2020) and Trautlein (2015) suggest that leaders should have strong orientations towards people (heart), purpose (head) and processes (hands) to effectively navigate through 4IR. Overall, when building on the literature reviewed above, the TVET institutional leaders directly influence the way transformations should take place to implement 4IR competencies into programme offerings. Further, they are required to constantly keep up with 4IR technological developments and effects on programme offerings as well as changing industry demands for skill supply. As presented in the introduction, the present study focused on how TVET leaders support the implementation of 4IR competencies into programme offerings in terms of financial support for digital transformations, support for partnership, job market sensitivity, support for changes to programme offerings, popularization of programme offerings, support for teacher development, and support for adherence to quality.

### 2.1 Securing Financial Support

In the wake of 4IR, higher education institutions must assess the effects of digitalization on prevailing as well as new vocations across industries. The focus of the present study is STEM fields, which implies the importance of the readiness of TVET systems to adapt in response to, especially, changing technological environment. Ubiquitous computing infrastructure, i.e., broadband, mobile broadband, and cloud computing, is a prerequisite to making most digital learning applications happen. These technologies “allow individuals to have access to practically unlimited information and computing resources, even from low-cost devices such as mobile phones, from anywhere in the world” (ILO, 2020, p.32). Mobile communication technology can be identified as the technology that has the highest impact on the TVET teaching and learning process (ILO, 2020). On the one hand, mobile

learning could make computer suites of educational institutes largely redundant when students are not required to travel to the educational institute (Whalley et al., 2021). On the other hand, mobile learning devices (smartphones and tablets) as adaptational and companion devices in the teaching and learning environment of Bring Your Own Devices (BYOD) enable ubiquitous computing infrastructure to be used effectively in any learning space with the capacity to improve student experience (Crompton et al., 2016; France et al., 2021; Whalley et al., 2021). COVID-19 showed the importance of ubiquitous computing infrastructure for the process of teaching and learning (Whalley et al., 2021). Further, TVET Academy (2021) provides examples of AR-compatible textbooks, which are intended to be used in TVET. In addition, Angel-Urdinola et al. (2021) provide evidence from a meta-analysis for the use of extended reality technologies in engineering, science, and technical education in TVET systems. Therefore, on the one hand, TVET systems should incorporate new or emerging technologies into the curriculum. On the other hand, should update teaching and learning approaches in line with technological advancements. These urge institutions to ensure appropriate technology infrastructure is available to be used in programme offerings. Hence, financial support is a must for investments in educational technologies. As per The World Bank Group (2021, p. xviii), reliable and regular funding mechanisms should be made available to “source, develop, maintain, and upgrade existing infrastructure and equipment”. TVET institutions must secure financial support from national, provincial, and local government levels, and private and non-profit donors to accomplish technological transformation at the institution level.

## 2.2 Multistakeholder Partnership

Multistakeholder partnership is identified as a powerful vehicle for digital transformations (ILO, 2020; The World Bank Group, 2021). Industry partners can be willing to pool resources to provide vital infrastructure for TVET programme delivery (The World Bank Group, 2021). TVET institutions should develop meaningful collaborations with employers for industry placements for trainees and for TVET staff to obtain vital exposure to new technologies in use. The literature identified the interconnections between funding or financial support availability, digital infrastructure, and partnerships (Rotatori et al., 2021; The World Bank Group, 2021; ILO, 2020). Systemic partnerships across national, regional, and local governments, not-for-profit sectors and for-profit business sectors can provide vital resources by way of financial, infrastructure, programme/curriculum development, and exposure to students and staff. In this regard, the World Bank Group (2021) provides ample evidence for such partnerships. Hence, TVET institutions should be willing and actively engaged in creating and maintaining partnerships.

## 2.3 Job Market Sensitivity, Changes to Programme Offerings, and Popularization

As mentioned above, two of the core functions of TVET are the design and development of training programmes and the delivery of training. According to the World Bank Group (2021, p.10), the design and development of training programmes involve processes of “mapping the curriculum, mapping content to outcomes, and defining teaching, learning, and assessment strategies and activities mapped to learning objectives” as well as “material development, which is the process of creating teaching and learning materials for skills development, using various media forms (for example, audio, video, print [both digital and physical], computer-based multimedia, simulations, virtual reality, gaming, etc.)”. The delivery of training involves “designing, implementing, and maintaining administrative systems and functions, ensuring efficient and effective student support, conducting audits and implementing feedback, monitoring program/course, assessing learners, and ensuring that record-keeping and data collection processes are efficient and feed back into the system” (The World Bank Group, 2021, p.10). Inevitably, any transformations to incorporate 4IR competencies into the design and development of training programmes and delivery of training require institutional support. When making changes to programme offerings, TVET institutions should show sensitivity to the labour market. Interactions with industry partners provide a better understanding of technical and transversal skills needed by employers (Amegah, 2023). According to ILO (2020), TVET institutions should improve their labour-market intelligence, and should attempt to respond to labour market requirements promptly through new programme offerings and/or changes to existing programmes to better equip trainees for the targeted job positions; in some situations, with appropriate entrepreneurial skills, trainees may create their jobs. This highlights another vital activity that TVET institutions must engage in – the popularization of programme offerings. In the era of 4IR, providing flexible learning options for a country’s youth and adults with a lifelong learning agenda is the ultimate target of TVET institutions. Hence, programme offerings, changes to programme offerings, and learning pathways need to be popularized across the target audiences.

## 2.4 Capacity Development of TVET Staff

One of the key requirements to incorporate 4IR competencies into programme offerings is the capacity development of TVET staff (ILO, 2020; The World Bank Group, 2021; TVET Academy, 2021). This is identified as

a core function of TVET. Staff capacity building involves the development of staff “to better meet the needs of learners and organizations and to respond to the labour market” (The World Bank Group, 2021, p.10, also refer to UNESCO-UNEVOC International Centre for TVET, 2020). According to ILO (2020, p.60), TVET teachers not only include teachers and instructors but also “media designers, programmers and subject matter experts” whose contribution is a must for the success with 4IR technologies. UNESCO-UNEVOC International Centre for TVET (2020, p. 7) also identifies TVET teachers as “teachers, instructors, trainers, tutors, managers, administrators, extension agents, guidance staff and others”. Hence, as part of capacity building, a TVET institution should develop and improve the capacity of its teachers in the broadest sense. TVET staff, those who mainly involved in programme design and delivery should be up to date with how 4IR influences the content-domain of a subject area and they should be capable of delivering the subject content using 4IR technologies. TVET staff, those who mainly involved in technical assistance should be up to date with hardware, software, and tools connected to 4IR technologies to support and advise when making decisions on teaching and learning approaches. TVET staff, those who mainly involved in administration in different capacities should be provided awareness on 4IR, required transformations, and facilitating and managing teaching and learning approaches. Since TVET staff should operate with the developments of 4IR, their digital skills should also be improved. In this regard, the World Bank Group (2021) and ILO (2020) state that teachers find difficulties in using digital technologies because of insufficient infrastructure at TVET institutions for them to access and/or lapse in their digital skills to use digital technologies in the teaching and learning process.

## 2.5 Adherence to Quality

Another core function to which attention and involvement is a must is adherence to quality in programme offerings (The World Bank Group, 2021). This is vital since 4IR is an era of globalization. A trainee passes out from a country’s TVET institution can be on the move for employment or permanent migration, i.e., skill mobility at the technician level. They should possess universally acceptable or accredited qualifications. This has a tremendous impact on the way TVET systems operate on a global scale. Therefore, adherence to quality, and continuous monitoring and evaluation at the level of TVET institutions are vital. At TVET institutions, quality control ensures programme offerings meet minimum acceptable standards, the promotion of quality culture across a TVET institution promotes joint responsibility, and the management of quality ensures continuous accomplishment of quality expectations of stakeholders. Since these activities involve an institution’s resources, encouragement and support from the TVET leaders are of utmost importance. In turn, monitoring and evaluation data on quality will help TVET leaders in effective decision-making (ILO, 2020).

## 2.6 Proposition – TVET Institution Type

The World Bank, ILO, and UNESCO over time have spread the need to create and maintain almost indistinguishable TVET systems regardless of the country in question, and introduced frameworks to reach this dream (UNESCO, 2016; UNESCO-ILO, 2018). These regional and even global frameworks aimed to increase the relevance of TVET programme offerings by considering the possibilities of skill mobility across countries for employment and permanent migration. These international, intergovernmental organizations also launched various initiatives to propagate the requirement of implementing 4IR competencies into TVET programme offerings (ILO, 2020; The World Bank Group, 2021). Due to these relentless efforts, there is a considerable understanding of 4IR and its impact on TVET at country, region, and global levels. However, as suggested by Rotatori et al. (2021), the relative readiness of individual nation-states in the implementation of 4IR competencies into TVET programme offerings could be hindered due to country-specific reasons. Accordingly, we propose that although countries adopted almost similar systems, differences can still be identified within the TEVT system of a country when scrutinising based on vital elements of a TVET system. One such element is the institution type. Our reading on the prevailing TVET systems led us to identify different types of TVET institutions operating in a country, i.e., TVET regulatory bodies, TVET teacher training and research institutes, TVET universities, polytechnics, and TVET colleges. We propose that the stakeholder involvement (such as the State and industry) and the way they collaborate may create conditions to find differences by the TVET institution type (refer to Persson and Hermelin, 2018). Therefore, we tested differences by the TVET institution type.

## 3. Methodology

### 3.1 Sample and Data Collection

The data were collected from the 15 countries shown in Table 1. Respondents were TVET staff engaged in STEM fields at the tertiary level. The Colombo Plan Staff College (CPSC), located in the Philippines, allowed access to its database to reach the sample of the study. The CPSC founded in 1973 is an Inter-Governmental Organization (IGO) of 26 member countries with a mission of uplifting TVET in Indo-Pacific region. One of its main roles is to conduct

teacher training programmes for TVET staff members (administration, academic, academic support, and technical) of member countries, which are known as *in-country programmes*. It has a member directory of around 2000 members who attended in-country programmes during the last three years from the countries selected for the study. We sent the link to the online survey questionnaire to TVET staff who had undergone in-country training programmes conducted by the CPSC during the last three years from the 15 countries described in Table 1, in mid-2022. After six weeks of the initial contact, we received 470 valid responses. Of the 470 respondents, 51% came from South Asia while 49% from East Asia & Pacific. Of the 470 respondents, 15% were belonging to TVET regulatory bodies, 26% from TVET teacher training/research institutes, 19% came from Polytechnic/TVET universities, and 40% came from TVET Colleges. An example for TVET regulatory body is Technical Education and Skills Development Authority (TESDA) in the Philippines. An example for TVET teacher training/research institutes is National Institute of Technical Teacher Training and Research (NITTTR) in India. Example for TVET university is University of Vocational Technology (UNIVOTEC) in Sri Lanka. An example for TVET College is Rajamangala University of Technology Thanyaburi in Thailand. Of the 470 respondents, 53% engaged as administrators, 34% engaged as academic staff, 2% engaged as academic support staff, and 11% engaged as technical staff. Of the 470 respondents, 33% had doctorate, 42% had master's degree, 16% had bachelor's degree, and 9% had Certificate, diploma, or higher diploma as the highest education level. Of the 470 respondents, 25% identified themselves as female while the remaining 75% identified themselves as males. The mean age of the 470 respondents is 47 years (standard deviation = 9, Minimum = 25, Maximum = 68, Skewness = .067).

### 3.2 Measures

The present study was conducted purely for academic purposes. Since we have not found previous studies that are within the scope of the present study, we developed all the item measures. We used three types of Likert scales, i.e., 7-point Likert (strongly agree = 7, agree = 6, More or less agree = 5, moderate = 4, More or less disagree = 3, disagree = 2, strongly disagree = 1), 5-point Likert scale (to a great extent = 5, much = 4, somewhat = 3, little = 2, not at all = 1), and 3-point Likert scale (comprehensive and well-implemented formal system exists = 3, formal system exists but with some gaps in implementation = 2, no such system = 1). The respondents used these three types of Likert scales to evaluate the eight areas under study, i.e., financial support for digital transformations, support for partnerships, job market sensitivity, support for changes to programme offerings, popularization of programme offerings, support for teacher development, support for adherence to quality, and the overall assessment of institution management in response to implementing 4IR competencies into programme offerings. The item measures and scales used to evaluate each area under study are described in detail in the results section.

### 3.3 Methods of Data Analysis

Wilks' Lambda statistic was used to test for differences by country; Wilks' Lambda statistics showed the non-existence of significant differences ( $p > 0.05$ ) by country. Tests were conducted to identify differences by the TVET institution type, i.e., TVET regulatory body, TVET teacher training/research institutes, polytechnic /TVET university, and TVET college. One-way ANOVA was used for the analysis. Partial eta squared (partial  $\eta^2$ ) was used to evaluate the effect size.

## 4. Findings

Table 2 shows the results for financial support for transformations in TVET institutions. Mean values together with standard error of the mean are shown in Table 2. Table 2 suggest that the availability of financial support schemes to address 4IR competencies is highest for teacher training/research institutions. The results show significant differences by institution type for the two areas, i.e., availability of financial support schemes to address 4IR competencies ( $p < .001$ ) and autonomy to increase revenues through marketing and branding of 4IR competencies ( $p < .001$ ). For these two areas, partial  $\eta^2$  values suggest that institution type accounts for 8% and 7% of the variance, respectively.

Table 3 shows the results for support for partnerships. Mean values together with standard error of the mean are shown in Table 3. Regarding the promotion of multi-stakeholder partnership, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 4% of the variance. Regarding holding awareness programmes on 4IR competencies and technologies to industry, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .001$ ). Partial  $\eta^2$  value suggest that institution type accounts for 6% of the variance. Regarding the availability of mechanisms for industry collaboration to address 4IR competencies, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .05$ ). Partial  $\eta^2$  value suggest that institution type accounts for 3% of the variance. Overall, the results show significant differences by institution type for all areas investigated.

**Table 2** Financial support for digital transformations

	Total	TVET	Teacher	Polytechnic/	TVET	F	Sig.	Partial
		regulatory	training/	TVET	college			$\eta^2$
		body	research	University				
			institute					
Availability of financial support schemes to address 4IR competencies	1.84 (.04)	1.90 (.13)	2.15 (.08)	1.65 (.08)	1.70 (.06)	7.87	.000	.078
Availability of financial support for infrastructure development to address 4IR competencies	2.06 (.04)	2.05 (.12)	2.23 (.08)	2.00 (.10)	1.97 (.06)	2.16	.093	.023
Autonomy to increase revenues through marketing and branding of 4IR competencies	1.85 (.04)	1.81 (.12)	2.16 (.09)	1.76 (.09)	1.69 (.06)	7.04	.000	.070
Overall financial support	1.91 (.04)	1.92 (.11)	2.18 (.07)	1.81 (.07)	1.79 (.05)	6.89	.000	.069

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; all the items on the 3-point scale.

**Table 3** Partnerships

	Total	TVET	Teacher	Polytechnic/	TVET	F	Sig.	Partial
		regulatory	training/	TVET	college			$\eta^2$
		body	research	university				
			institute					
Promotes multi-stakeholder partnership to address 4IR competencies <sup>‡</sup>	5.18 (.09)	5.33 (.25)	5.69 (.17)	5.00 (.22)	4.87 (.16)	4.34	.005	.044
Conducts awareness programmes on 4IR competencies and technologies to industry <sup>‡</sup>	5.03 (.10)	5.07 (.27)	5.72 (.16)	4.73 (.22)	4.70 (.16)	6.73	.000	.067
Availability of mechanisms for industry collaboration to address 4IR competencies <sup>◇</sup>	2.01 (.04)	2.02 (.11)	2.17 (.07)	1.93 (.08)	1.93 (.06)	3.11	.027	.032

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; <sup>‡</sup> = 7-point scale; <sup>◇</sup> = 3-point scale. Overall combined value was not calculated since scales of the items are not the same.

Table 4 shows the results for job market sensitivity. Mean values together with standard error of the mean are shown in Table 4. Regarding monitoring job market outcomes of students, TVET colleges scored the highest. However, the results do not show significant differences by institution type ( $p > .05$ ). Regarding responsiveness to job market changes, teacher training/research institutions scored the highest. However, the results do not show significant differences by institution type ( $p > .05$ ). Overall, the results do not show significant differences by institution type for all areas investigated.

**Table 4** Job market sensitivity

	Total	TVET	Teacher	Polytechnic/	TVET	F	Sig.	Partial
		regulatory	training/	TVET	college			$\eta^2$
		body	research	University				
			institute					
Monitors the job market outcomes of our students	4.01 (.04)	3.99 (.09)	3.99 (.08)	4.01 (.10)	4.05 (.06)	.14	.936	.001
TVET in my country is highly responsive to job market changes	3.96 (.04)	3.92 (.11)	4.03 (.08)	3.90 (.10)	3.97 (.06)	.42	.740	.002
Overall job market sensitivity	3.99 (.04)	3.96 (.09)	4.01 (.08)	3.95 (.09)	4.00 (.06)	.15	.925	.001

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; all the items on the 5-point scale.

Table 5 shows the results for support for changes to programme offerings. Mean values together with standard error of the mean are shown in Table 5. Regarding support for curriculum development to incorporate 4IR competencies, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 5% of the variance. Regarding support to adopt 4IR technologies in teaching delivery, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 4% of the variance. Regarding flexibility to incorporate 4IR competencies into accreditation and certification, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 5% of the variance. Overall, the results show significant differences by institution type for all areas investigated.

**Table 5** Changes to programme offerings

	Total	TVET regulatory body	Teacher training/research institute	Polytechnic/TVET University	TVET college	F	Sig.	Partial $\eta^2$
Support for curriculum development to incorporate 4IR competencies <sup>‡</sup>	2.04 (.04)	2.17 (.10)	2.21 (.07)	1.93 (.09)	1.92 (.06)	4.44	.005	.045
Support to adopt 4IR technologies in teaching delivery <sup>‡</sup>	2.13 (.04)	2.14 (.09)	2.32 (.07)	2.11 (.08)	2.00 (.05)	4.32	.005	.044
Flexibility to incorporate 4IR competencies into accreditation and certification <sup>◊</sup>	2.04 (.04)	2.10 (.11)	2.25 (.08)	1.89 (.08)	1.96 (.06)	4.42	.005	.045
Overall changes to programme offerings	2.07 (.03)	2.13 (.09)	2.26 (.06)	1.98 (.07)	1.96 (.05)	5.43	.001	.055

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; all the items on the 3-point scale.

Table 6 shows the results for the popularization of programme offerings. Mean values together with standard error of the mean are shown in Table 6. Regarding the provision of up-to-date programme/course information for youth and adults, polytechnic/TVET universities scored the highest. However, the results do not show significant differences by institution type ( $p > .05$ ). Regarding the provision of information on programmes/courses for youth and adults, TVET colleges scored the highest. However, the results do not show significant differences by institution type ( $p > .05$ ). Overall, the results do not show significant differences by institution type for all areas investigated.

**Table 6** Popularization of programme offerings

	Total	TVET regulatory body	Teacher training/research institute	Polytechnic/TVET University	TVET college	F	Sig.	Partial $\eta^2$
Provision of up-to-date programme/course information for youth and adults	4.05 (.04)	3.99 (.09)	4.06 (.09)	4.08 (.08)	4.05 (.06)	.19	.903	.001
Information on programmes/courses is readily available for youth and adults	4.17 (.04)	4.31 (.08)	4.14 (.09)	4.13 (.09)	4.16 (.06)	.87	.458	.005
Overall popularization of programme offerings	4.11 (.04)	4.14 (.08)	4.07 (.07)	4.02 (.08)	4.10 (.05)	.07	.975	.000

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; all the items on the 5-point scale.

Table 7 shows the results for support for staff development. Mean values together with standard error of the mean are shown in Table 7. Regarding the introduction of programmes to enhance digital literacy of staff, teacher

training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 5% of the variance. Regarding recommending training programmes for staff to improve 4IR skills and technologies, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .05$ ). Partial  $\eta^2$  value suggest that institution type accounts for 4% of the variance. Regarding the provision of an understanding on 4IR competencies that should be developed by staff, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 6% of the variance. Overall, the results show significant differences by institution type for all areas investigated.

**Table 7 Staff development**

	Total	TVET	Teacher	Polytechnic/	TVET	F	Sig.	Partial
		regulatory	training/	TVET	college			$\eta^2$
		body	research	University				
			institute					
Programmes were introduced to enhance digital literacy of staff	5.20 (.09)	4.95 (.26)	5.72 (.15)	5.20 (.17)	4.94 (.15)	4.74	.003	.048
Training programmes are recommended for staff to improve 4IR skills and technologies	5.22 (.09)	5.24 (.22)	5.71 (.15)	4.91 (.21)	5.04 (.16)	3.71	.012	.038
Provided an understanding on 4IR competencies that should be developed by staff	5.14 (.09)	5.33 (.25)	5.73 (.16)	4.95 (.23)	4.78 (.16)	5.65	.001	.057
Overall staff development	5.19 (.09)	5.17 (.22)	5.72 (.14)	5.02 (.18)	4.92 (.14)	5.13	.002	.052

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; all the items on the 7-point scale.

Table 8 shows that support for adherence to quality. Mean values together with standard error of the mean are shown in Table 8. Regarding the support for adherence to quality, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .001$ ). Partial  $\eta^2$  value suggest that institution type accounts for 6% of the variance.

**Table 8 Adherence to quality**

	Total	TVET	Teacher	Polytechnic/	TVET	F	Sig.	Partial
		regulatory	training/	TVET	college			$\eta^2$
		body	research	University				
			institute					
A mechanism for quality assurance that integrated 4IR requirements is available	2.00 (.04)	2.00 (.11)	2.27 (.07)	1.91 (.08)	1.88 (.06)	6.10	.000	.061

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; Single item measure; the item on the 3-point scale

Table 9 shows the results for the overall assessment of institution management. Mean values together with standard error of the mean are shown in Table 9. Regarding the encouragement to learn from past experience and deal effectively with 4IR challenges, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 5% of the variance. Regarding mechanisms are available to collect, process, analyse and disseminate information that is required for formulating and evaluating policy for 4IR, teacher training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 5% of the variance. Regarding the provision of a safe teaching and learning environment for all, teacher training/research institutions and TVET colleges scored the highest mean value of 4.21. However, the results do not show significant differences by institution type ( $p > .05$ ). Regarding whether the institution's strategic goals are people-oriented, purpose-oriented and process-oriented toward 4IR, teacher

training/research institutions scored the highest. The results show significant differences by institution type ( $p < .01$ ). Partial  $\eta^2$  value suggest that institution type accounts for 5% of the variance.

**Table 9 Overall assessment**

	Total	TVET regulatory body	Teacher training/ research institute	Polytechnic/ TVET University	TVET college	F	Sig.	Partial $\eta^2$
Encouraged to learn from past experience and deal effectively with 4IR challenges <sup>±</sup>	5.07 (.09)	5.24 (.23)	5.57 (.18)	4.91 (.19)	4.74 (.15)	4.69	.003	.048
Mechanisms are available to collect, process, analyse and disseminate information that is required for formulating and evaluating policy for 4IR <sup>◇</sup>	1.95 (.04)	1.95 (.12)	2.20 (.08)	1.89 (.08)	1.82 (.06)	5.33	.001	.054
My institution provides a safe teaching and learning environment for all <sup>▪</sup>	4.19 (.04)	4.11 (.08)	4.21 (.08)	4.20 (.08)	4.21 (.06)	.33	.803	.002
Overall, my institution's strategic goals are people-oriented, purpose-oriented and process-oriented toward 4IR <sup>±</sup>	5.20 (.09)	5.33 (.24)	5.69 (.18)	5.18 (.21)	4.82 (.15)	4.75	.003	.048

Notes: Mean and standard error of the mean (SE) for the total sample and by institution type. SE in brackets; <sup>±</sup> = 7-point scale; <sup>◇</sup> = 3-point scale, <sup>▪</sup> = 5-point scale. Overall combined value was not calculated since scales of the items are not the same.

### 5. Discussion and Implications

The study investigated how TVET staff engaged in STEM fields belonging to different types of TVET institutions perceived the response of their respective institutions to implementing 4IR competencies into programme offerings. Although 4IR technologies are making a profound impact on the digitalisation of pedagogies across countries, regions, and continents (Kaume-Mwinzi, 2016; Pima, 2019; Schröder, 2019), empirical studies on TVET are very rare. Previous empirical studies on TVET institutions in the backdrop of 4IR are still nascent. Case-based or single country-based experiences available in the mainstream literature are insufficient for informed decision-making. For the growth of TVET systems, more broad-based empirical studies are vital.

For our study, TVET staff engaged in TVET regulatory bodies, TVET teacher training and research institutes, TVET universities, polytechnics, and TVET colleges from 15 countries in Indo-Pacific responded to the survey. In the data analysis, Wilks' Lambda statistic showed the non-existence of significant differences ( $p > 0.05$ ) by country. This could be a result of relentless efforts by the international and intergovernmental bodies (UNESCO, 2016; UNESCO-ILO, 2018) to create and maintain almost indistinguishable TVET systems in the world, which allows middle-level technical skill migration across the world to occur smoothly. Still, the relative readiness of individual nation-states could differ based on country-specific contextual factors. Identifying TVET institution type as such a factor, we tested differences between four types of TVET institutions. Therefore, our study makes several contributions to the literature and practice.

The results of our study revealed how institutions' response to implementing 4IR competencies into programme offerings under eight themes, namely, financial support for digital transformations, support for partnerships, job market sensitivity, support for changes to programme offerings, popularization of programme offerings, support for teacher development, support for adherence to quality, and the overall assessment of institution management in response. Our results support the arguments of Schröder (2019) that 4IR technologies should increasingly become a part of TVET programme offerings. The findings showed significant differences in the perceptions of TVET staff for their respective institution's response to implementing 4IR competencies into programme offerings (Tables 2 to 9). For example, our results collaborate with ILO (2020) and Pima (2019) that staff should have requisite knowledge, especially technological knowledge, and requisite level of digital competencies to adjust to 4IR environment. Further, our results support the arguments of Gonçalves (2019) that TVET institutions should have invested on equipment, computer hardware, software and communication network for digital delivery for the institutional implementation of 4IR competencies into programme offerings. As elaborated in the sections 5.1 and 5.1 too, the findings of the study substantiate the arguments of in the literature such as Kaume-Mwinzi (2016), TVET Academy (2021), UNESCO (2016); UNESCO-ILO (2018).

## 5.1 Contribution to Existing Literature

Concerning the contribution of the study to the existing literature, the findings of the present study provide novel and important findings for Indo-Pacific in several spheres. First, as mentioned in the introduction, past empirical studies on TVET in Indo-Pacific in the 4IR era are rare. The available studies offer case-based or single country-based experiences, which are insufficient for academics, practitioners, and policymakers to make informed decisions.

Second, recent advancements in digital technologies may lead to create a teaching and learning context that is inevitably becoming digital. The teaching and learning context at TVET is different from K-12 (primary and secondary) and the higher education setting of a university. Programmes of TVET in STEM fields at the tertiary level required to use the most appropriate instructional approaches to provide both theory and hands-on practice required for the vocations across industries with high emblematical fidelity and pragmatism. The digitalization in TVET institutions could provide the required leap to minimize the gap between theory and hands-on practice. However, the extant literature does not provide sufficient information on the digitalization happening in TVET institutions in STEM fields.

Third, the literature suggests that low- and middle-income countries face challenges in the digitalization of TVET institutions; still, some form of digitalization can be seen in the TVET institutions in these countries (see TVET Academy, 2021). The 10 areas were investigated in the present study to substantiate institution support, namely, financial support for digital transformations, support for partnership, job market sensitivity, support for changes to programme offerings, popularization of programmes, support for teacher development, and support for adherence to quality, and the overall assessment of institution management. The findings provide valuable insight into the challenges faced by the countries. Therefore, our study about TVET institutions in STEM fields at the tertiary level across 15 Asian countries is novel and makes important contributions to the literature.

Fourth, although evaluation and monitoring of achievements in the implementation of 4IR competencies is important for any educational institute, to date there are no indicators or standard measures for this purpose. In most situations, having statistical indicators (such as ratios) may not be viable, and pooling of stakeholder perceptions may become the most appropriate. For the present study, we developed measures to evaluate the implementation of 4IR competencies. These measures were used across 15 countries. Therefore, we identify this as one of the most important contributions of the study. Future studies can use the same or could build on our measures.

## 5.2 Implications to Practice

The findings of the present study provide important implications for higher education institutions, personnel in their leadership positions, and policymakers when moulding youth and adults for the 4IR industrial landscape. First, it is apparent from the findings shown in Tables 2 to 9 that the responses of TVET teacher training and research institutes are far ahead of the other types of institutions; TVET colleges are positioned at the lowest level. Overall, the findings show scope for all types of institutions to advance in their responses in the implementation of 4IR competencies into programme offerings and highlight the need to make the responses of all TVET institutions almost alike.

Second, if education is viewed as an asset and instrument of society, society can set pace and targets for education (refer to Kaume-Mwinzi, 2016). For the advancement of economies and society, industrial sectors (production and service) highly sought for personnel with 4IR competencies. Youth and adults look for avenues for skill acquisition to be employed and to retain employment in the era of 4IR. Education institutions that are lagging behind in responding to 4IR demands may experience unfavourable consequences such as a decrease in student enrolments, difficulties in finding internship placements and volunteer projects for students, and a decrease in industry funding and other partnership benefits to name a few at the immediate institutional level. This excludes the consequences of not producing graduates with the desired competencies for a country's economic and social development. Therefore, TVET institutions must be more purpose-oriented in their implementations.

Third, the future of TVET institutions is being shaped today by the way they position themselves along with the development of 4IR technologies. When seeing that TVET institutions must be driven and shaped by their leaders, personnel in the leadership positions of TVET institutions must be able to navigate their respective institutions through the transformations required by the 4IR. However, it is possible that although institutional leaders have worked for decades, this could be their first encounter with an industrial revolution requiring massive technological transformations in programme offerings and a makeover in the supply of skills to the labour market. Therefore, institutional leaders with appropriate capabilities and a good understanding of 4IR requirements could sharpen institutional response to better implement 4IR competencies into programme offerings.

## 6. Conclusion

Based on the findings of the study, it can be concluded that institutional response to implementing 4IR competencies into programme offerings can be explained under eight themes, namely, financial support for digital transformations, support for partnerships, job market sensitivity, support for changes to programme offerings, popularization of programme offerings, support for teacher development, support for adherence to quality, and the overall assessment of institution management in response. The results support our argument that significant differences exist in the perceptions of TVET staff for their respective institution's response to implementing 4IR competencies into programme offerings.

## 7. Limitations and Future Research

Despite the novelty and importance of the findings of the present study, some limitations should be acknowledged. The study was conducted using survey methodology to obtain a broad-based picture of TVET in Asian and the Pacific region in response to the developments of 4IR. Hence, the depth of information or the magnitude of detail provided on each area investigated may need further improvements. Considering the fact that non-existence of previous empirical studies having the scope of the present study in the extant literature, future studies with more depth and breadth can be designed based on the findings of the present study. Further, although every TVET institution can maintain its policies to direct its institutional outlook, country-wide policies and procedures adopted could lead to more uniform implementations of 4IR competencies into programme offerings. However, evaluating policy levers used was beyond the scope of the present study. Future research could investigate the effectiveness of global, regional, and national policy levers in implementing 4IR competencies at TVET institutions or whether some tailoring is required for a better fit at the institutional level. Furthermore, we find the importance of collecting data on student experiences on internships and volunteer projects in the industry during their study period to identify any skill gaps or areas where higher education institutions should concentrate more. Since the ultimate purpose of TVET institutions is to supply skilled personnel to the labour market, it is also important to collect data on labour market outcomes after passing out from TVET institutions.

## Acknowledgement

The authors would like to thank those involved in the completion of this research.

## Conflict of Interest

There is no conflict of interests regarding the publication of the paper. The study does not involve funding, employment, financial or non-financial related conflicts of interest to disclose.

## Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** G.L.D. Wickramasinghe, V. Wickramasinghe; **data collection:** G.L.D. Wickramasinghe; **analysis and interpretation of results:** G.L.D. Wickramasinghe, V. Wickramasinghe; **draft manuscript preparation:** V. Wickramasinghe. Both authors reviewed the results and approved the final version of the manuscript.*

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