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Technical and Vocational Education and Training in Asia and the Pacific –It's Matter for Economic Performance with the 4th Industrial Revolution

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ABSTRACT

The very nature of work, labor market composition, and skill requirements are severely affected by technology-driven transformations currently underway with the 4th industrial revolution (4IR). The effect of 4IR technologies on technical and vocational education and training (TVET) and the contribution of TVET to the labor market is explicit. The paper presents the findings of a study that investigated whether TVET institutions are prepared to face the challenges of 4IR. The data for the study were collected by surveying 428 teachers from 15 countries in Asia and the Pacific engaged in science, technology, engineering, and mathematics (STEM) fields at the tertiary level. The findings of our study undoubtedly bring greater attention to the initiatives of TVET in these countries in preparing the workforce for job roles necessitated in the 4IR. The findings can also be used to frame policy recommendations for the growth of economies.

KEYWORDS

4th industrial revolution; technical and vocational education and training; TVET; Asia, South Asia, East Asia

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1. Introduction

In the present day, the demand for education and the need for alternative educational opportunities are rising. Concerns over the effects of education on subsequent outcomes are of interest to many stakeholders as education boosts the growth of economies. A constant supply of skilled workers with up-to-date competencies creates opportunities for technological adoption, the modernization of industries, and trade competitiveness. Since education is associated with benefits to society at large (Rosmiler and Geske, 1977), countries expect large returns from investments in it. It is also evident that the interest in education in the economics literature mostly concentrates on schools (Asian Development Bank [ADB], 2021; Karmel, 2010) while technical and vocational education and training (TVET) has not drawn much attention so far. The TVET system of a country is comprised of education, training, and skills development in various occupational fields, production processes, services, and livelihoods (International Labour Organization [ILO], 2020, p. 21). TVET institutions provide work-based learning, continuing training, and professional development programs leading to qualifications as well as a wide range of skill development options as lifelong learning across three levels - secondary, post-secondary and tertiary (ILO, 2020, p. 21). Since TVET aims to supply middle-level skilled manpower for economic activities of an economy there is an interest in and demand for data on outcomes of TVET institutions and the effectiveness of program offerings in responding to demands of the labor market.

In the present paper, we argue that the way education, specifically TVET, is perceived and provided should be changed to gain success along with the 4th industrial revolution (4IR) technologies. When framing TVET within 4IR, an understanding of the present context is of utmost importance. On the one hand, the world we currently live in is identified as VUCA, i.e., volatile, uncertain, complex, and ambiguous (Millar et al., 2018). Survival and growth in this world demand a shift in kind rather than degree (Schoemaker et al., 2018), suggesting that organizations should altogether replace their already tried and tested approaches with new ones. The TVET system should embrace VUCA when looking forward, where the TVET system and trainees/potential trainees constantly cope with conflicts from value and value for money on the program offerings. On the other hand, since the first quarter of the 21st century society is experiencing dramatic changes that can be attributed to 4IR. The 4IR technologies are expected to fundamentally change the way society interacts with each other, lives, and works in the coming decades (Hirschi, 2018; World Economic Forum, 2016). Transformations are becoming unprecedented in terms of scale, speed and complexity compared to the experiences of previous industrial revolutions (Schwab, 2016). Businesses must increasingly rely on digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), 3D printing, and robotics for survival and growth. To succeed, operational technologies tried and tested so far must be altogether replaced with 4IR technologies (Goger et al., 2022; Schoemaker et al., 2018; Whalley et al., 2021). However, unlike the technologies brought by previous industrial revolutions that made clear boundaries between technology and people, 4IR technologies cross the boundaries and demand changes in the way people interact with the technologies (Harel, 2020; World Economic Forum, 2016). For example, Harel (2020) states that previous industrial revolutions led to replacing physical labor with technologies whereas 4IR does not aim at replacing but rather demands humans use the technology for higher human productivity. As reviewed in the next section, this leads to profound changes in industrial structure, labor market structure, and qualification/skill requirements of the workforce.

If industries of a country must adopt new technologies, the TVET system should supply personnel capable of working with new technologies. If the country aims to establish and maintain a TVET system capable of providing employment in decent jobs or promoting entrepreneurship, incorporating 4IR competencies into program offerings is a must. Hence, 4IR is having far-reaching consequences for the higher education sector (Jung, 2020; Hirschi, 2018). If the regulatory framework of a country does not respond to the changes in the global technological environment, its TVET system may become fragmented from current global 4IR developments without proper guidance and regulations. Hence, when technologies change, countries should adapt accordingly, i.e., regulatory

frameworks, business sectors (product and service), and education institutions. Given the importance, business and education sectors adapting to 4IR technologies have become a part of the national frameworks of countries with futuristic perspectives (refer to World Economic Forum, 2016). However, the recent literature suggests that States and policy-making bodies, industry (product/service), and educational institutions are struggling to evolve along with the transformations led by 4IR and the industry is coping with an inadequate pool of workers sufficiently equipped with the necessary 4IR competencies (Hirschi, 2018).

While the trends of the future of work with 4IR have been pronounced (UNESCO-ILO, 2018; World Economic Forum, 2016), an understanding of the response of TVET in accommodating 4IR and how regulatory frameworks should be used to boost TVET institutions' response is limited in the mainstream literature. The present study investigated whether TVET institutions are prepared to face the challenges of 4IR. The specific objectives of the study were to investigate whether 1) TVET institutions receive support to leverage 4IR developments, 2) TVET institutions support the capacity development of teachers to incorporate 4IR competencies into program offerings, 3) TVET institutions have incorporated 4IR competencies into program offerings, and 4) 4IR technologies are in use for the program delivery at TVET institutions. We evaluated the 'actions already taken' instead of 'intend to do' or 'identified as important to do'. Although the mainstream economics literature shows a lack of interest in empirical surveys that aim to understand the perceptions of people involved in the education system to evaluate achievements (McEwan, 2010; Schwerdt and Woessmann, 2020), we believe that it will take a long time to obtain real data on education sector's response to 4IR for regression modelling across countries. The present paper provides findings of a study that collected data from 428 TVET teachers from 15 countries in Asia and the Pacific regarding their respective TVET systems' response to incorporating 4IR competencies and technologies into program offerings in science, technology, engineering, and mathematics (STEM) fields at the tertiary level. In response to our survey questionnaire, TVET teachers provided rich data and unique insights into TVET program offerings. We believe that the findings presented in this paper are of value for the advancement of education systems and ultimately the performance of economies.

2. Review of Literature

2.1. 4IR on Industrial Structure, Labor Market, and Higher Education

4IR is expected to make three major shifts in connection to industrial structure, labor market, and higher education (Jung, 2020; Schröder, 2019; Spöttl and Windelband, 2021). Regarding shifts in connection to the industrial structure, an organization's organization of work, work processes, and the division of labor can experience a distinctive effect. Many labor-intensive jobs can be replaced with tools and systems built on artificial intelligence and robotics that could lead to wiped-out such jobs. If a country's competitiveness is built on low-cost manufacturing exports it could be at risk due to 4IR technologies (World Economic Forum, 2018). It is suggested that most low-skilled jobs in export-based sectors in Asia will suffer, and Asian economies may experience some of their low-wage export-based sectors shifting back to high-tech, higher-wage economies (ADB, 2018). With special reference to Asia, the ADB (2018) predicts that low- and routine-skilled and low-wage sectors such as apparel manufacturing in Asia will be seriously affected by 4IR technologies; such sectors may lose their competitive advantage; industry relocations to high-tech countries can be expected irrespective of higher-wage rates prevailing in these countries. Lordon (2014, p. 40) identified this as 'a shift in favor of capital away from labor'. Still, low-skilled jobs involving physical tasks such as transportation via work-on-demand apps (e.g., Grab and Foodpanda) will increase (Hirschi, 2018). Further, some knowledge and skill-based sectors involving information and communication technologies and digital media such as social media and crowd work will assume greater importance (ADB, 2018; Hirschi, 2018).

Regarding shifts in connection to the labor market, three scenarios - downgrade scenario, upgrade scenario, and polarization scenario, can be identified with 4IR (Schröder, 2019). In the downgrade scenario, technological unemployment will be the main problem, where numerous jobs involving operative, logistical, and administrative-level tasks will be replaced by artificial intelligence and robots (Schröder, 2019; Jung, 2020; Schwab, 2016). In the upgrade scenario, humans will be able to retain jobs involving planning, designing, data interpretation, decision-making, installation, maintenance, and troubleshooting; the demand for these jobs may also increase. Still, these jobs will require capabilities in information and communication technologies, digital media, and transversal skills to mediate between work processes involving both physical and virtual dimensions (Jung, 2020; Hirschi, 2018; Schröder, 2019). In the polarization scenario, deskilling of some job tasks and upskilling of some other job tasks will become prominent (Schröder, 2019). For example, machine operators are not required to read manuals and thoroughly understand or memorize the internal processes of machines but need to have digital literacy to follow instructions provided by digital devices and tutorials while working in digitally networked operation systems. Hence, the World Bank Group (2021, p. vii) states, 'Skills adaptability, upskilling, and reskilling will become critical attributes for workers and job seekers alike'.

Regarding shifts in connection to higher education, as a sequel to 4IR, higher education institutions should adjust their program offerings to suit the needs and demands of labor markets that emanate from 4IR (Spöttl and Windelband, 2021; World Economic Forum, 2016). 4IR has specified the worker capabilities required to perform jobs and avenues through which they should gain these capabilities. In the context of TVET, studies (such as Bhattacharyya and Mitra, 2020; Darvas and Palmer, 2014; Jabarullah and Hussain, 2019; Reeve, 2016; Schröder, 2019; Spöttl and Windelband, 2021) emphasizes the need of addressing 4IR worker capabilities in TVET programs. However, so far, to what extent TVET institutions have taken steps to address 4IR requirements is not clear due to the lack of statistics and empirical studies covering this important area. If higher education institutions fail to adapt, on the one hand, they will lose their ground to remain relevant. Hence, the higher education sector, in general, is under pressure to change and adapt. On the other hand, workers and job seekers should develop capabilities required by labor markets to be able to stay relevant; those who continuously orient his/her capabilities to match the requirements of 4IR will secure their jobs, move to better jobs, and experience more favorable career prospects.

2.2. Human Capital and TVET

The term human capital conveys the idea that the skills and productive capacity of individuals are of value (in fact resources) and represent a part of the stock of capital available to a society (Hanushek, 2015; Rosmiler and Geske, 1977). An individual's investment in higher levels of education yields him/her more favorable labor market outcomes such as increased earning potential (ADB, 2021; Carneiro et al., 2010); individuals and their families may also enjoy a myriad of noneconomic benefits (Brewer et al., 2010). From the societal point of view, the level of education attainment of the labor force is critical for macroeconomic stability (Brewer et al., 2010). Hence, governments invest in human capital for continued economic growth (Collier et al., 2008; Brewer et al., 2010).

In the higher education system of a country, traditional university degrees are still the gold standard for white-collar and elite jobs. TVET across countries has been stratified as a relatively inferior educational system, an inferior pathway to the labor market, and a terminal pathway to career progression in comparison to traditional university degrees (Naziz, 2019). TVET institutions are also understood as an outlet for relatively less-able individuals (such as school dropouts) and underprivileged communities of society (Ling, 2015). Hence, TVET is expected to deal with social disadvantage by providing more access for disadvantaged groups of society (Agrawal, 2012; Karmel, 2010; UNESCO, 2016). In addition, countries worldwide face constant challenges to social stability, both external and internal. Resilient social systems allow societies to respond decisively and bounce back quickly from sudden changes and disruptions. Individuals equipped with TVET qualifications and competencies are vital assets for a

country's resilience building due to its closeness to the labor market and its contribution to economic sectors' functioning (Jabarullah and Hussain, 2019; Hall and Soskice, 2001). Hence, one of the avenues identified for building a country's resilience is through investments in TVET (UNESCO-UNEVOC International Centre for TVET, 2020). Overall, what TVET programs offer has broader economic interests.

Trainees passed-out from TVET institutions mainly contribute to a country's low and middle-level skilled manpower at the subprofessional level. 4IR-related transformations demand TVET trainees to enter the labor force having knowledge of 4IR technologies and equipped with skills to work with devices and tools of 4IR technologies. However, recent literature from the countries under study suggests a lack of supply of skilled manpower at the subprofessional level (e.g., Bhattacharyya and Mitra, 2020; Butt et al., 2020). Further, questions the quality of supply of skilled manpower by TVET institutions (e.g., Jabarullah and Hussain, 2019). While elaborating experiences of TVET institutions in the implementation of 4IR competencies, the UNESCO-UNEVOC International Centre for TVET (2020) states that the implementation of 4IR competencies is a difficult task since it places tremendous demands on institutional resources. In a similar vein, recent studies such as Gonçalves (2019) and Schröder (2019) suggest that challenges faced by TVET institutions in the implementation of 4IR competencies are not confined to TVET institutions of one particular country in Asia but common to TVET institutions in Asia as a whole. UNESCO-UNEVOC International Centre for TVET (2020), further, states that futuristic TVET institutions should 'build the necessary institutional capacities to ensure the relevance of TVET to current and evolving needs in the world of work, nationally, regionally and internationally' (p.7). In addition to equipping youths (or first-time job seekers), TVET institutes should shoulder the responsibility of training working adults through continuing education options. After being identified with the need for reskilling and upskilling, working adults may return to TVET institutions to remain employable - maintain present employment and gain better future employment prospects. Hence, from TVET trainees' and working adults' point of view, TVET trainees receive basic or foundation skills (most often) from the state-run TVET institutions that collaborate with industry partners in the provision of apprenticeship training; state-run TVET institutions and other private training providers deliver lifelong education or retraining as re-skilling and upskilling programs for working adults (ILO, 2020).

2.3. Education Production at TVET Institutions and 4IR

To date, TVET systems in almost all countries are designed and developed through public expenditure, and these are mostly influenced by each country's economic characteristics and labor market relations (Hall and Soskice, 2001). Further, a country's TVET system is mainly maintained through government investments through public expenditures with some participation of not-for-profit and for-profit private donors (Hall and Soskice, 2001). Although TVET programs are offered through market mechanisms, the outcomes of the programs are of importance and value to society and the functioning of economic sectors. Hence, it is within the interests of any country to understand how it organizes and uses the limited resources to produce the required skilled manpower through TVET to respond to the demands of the labor market. This has become of utmost importance with the 4IR. In the education production system, the main inputs are the characteristics of an education institute. These include staff, software and equipment, program curricula and other resources that must be supplied to obtain the main achievements or outputs. The main outputs are the passed-out students - the number of passed-out trainees and the market relevance of skills gained by them (Brewer et al., 2010).

2.3.1. Inputs

Inputs are expected to improve the quality and relevance of education provision. 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). The teaching and learning context at TVET is

different from K-12 (primary and secondary) and the higher education setting of a university. Technical and vocational education and training is built on theory, practice, and workplace learning. The programs of TVET in STEM fields at the tertiary level required to use most appropriate instructional approaches to provide both theory and hands-on practice required for vocations across industries with high emblematical fidelity and pragmatism.

The impact of 4IR on TVET program offerings represents fundamental shifts in what is taught, how it is taught, and to whom it is taught. In other words, it is understood as digital adaptation and digital innovation (ILO, 2020, p. 25). Digital adaptation denotes 'how 4IR technologies require teaching new content' whereas digital innovation denotes 'how 4IR technologies enable new forms of teaching and learning'. Specifically, first, 4IR technologies must be incorporated into the subject content of the programs, i.e., advancements in teaching content. Second, 4IR technologies must be used for subject content delivery, i.e., advancements in tools and techniques used in the teaching and learning process as well as increased access to program offerings (ILO, 2020; The World Bank Group, 2021; UNESCO-UNEVOC International Centre for TVET, 2020). ILO (2020) provides ample evidence to suggest that many countries do not have a coherent strategy for digital adaptation and innovation to suit 4IR requirements. ILO (2020, p.69) further states 'our study only found limited evidence of explicit macro-level strategies to increase efficiencies and/or the impact of TVET through the use of digitization – nor has digitization of TVET or skills development been mentioned as a potential accelerator for desirable social changes. … Notable exceptions to this approach can be found in Ghana and New Zealand, which have managed to deploy system-wide modernization strategies for TVET'. At the national level of individual countries, one of the reasons for this situation is that the responsibility for designing and developing skill systems is distributed among numerous actors. This, at large, hinders a county's effective response to 4IR. Therefore, countries must do more to catch-up. The below paragraphs review the literature on incorporating new subject content to address 4IR competencies as well as delivery of subject content with 4IR technologies and increase access to TVET program offerings with the use of 4IR technologies.

Regarding subject content, UNESCO (2021a, 2021b, 2021c) identifies the importance of identification, integration, and implementation of competencies. Identification involves efficient and rapid identification of qualifications and competencies, integration involves prioritization and integration of qualifications and competencies into curricula and training regulations whereas implementation involves the effective implementation of qualifications and competencies into learning environments (UNESCO, 2021c, p. 9). Since TVET is built on both theory and hands-on practice, ILO (2020, p.60) state, 'more complex and involved digital workflows in the industry require these workflows to also be reflected in TVET institutions. […] Continued digitization of processes within the industry means that workers need to return to education or training at several stages across their working careers to remain relevant. […] Typically, workers and companies prefer that such education or training is either seamlessly integrated into the workplace or can take place simultaneously to workplace demands, without disrupting normal workflows'. This emphasizes the need of introducing bridging programs (reskilling and upskilling) for working adults without disrupting the normal workflows of the industry (ILO, 2020; The World Bank Group, 2021). To this end, TVET institutions should be capable of updating curricular, incorporating emerging subject content, and introducing bridging programs. However, studies such as Butt et al. (2020) highlight the challenges faced by education institutions in Pakistan in curriculum development in addressing 4IR requirements. One of the effective avenues to overcome this hurdle is initiating and maintaining partnerships. In this regard, the World Bank Group (2021, p. xix) provides evidence for a range of partnership possibilities, such as between industry and government, between industry and TVET institutions, and between government and donors - local or foreign. If TVET institutions develop appropriate partnerships, these may lead to introducing re-skilling and upskilling programs, curricular co-designed with industry partners, and micro-credentials to increase the market relevance of the TVET provision.

Regarding the use of 4IR technologies for subject content delivery or the digitalization of pedagogies, technologies such as ubiquitous computing infrastructure, collaboration technologies, extended reality technologies, and artificial intelligence allow the use of digital platforms such as social media platforms, video conferencing platforms, open online educational resources, massive open online courses (MOOCs), and learning management systems (LMS) in the teaching and learning process. These platforms can provide the required leap to minimize the gap between theory and hands-on practice. That is, the relevance of education can also be increased through 4IR technologies by bridging the gap between the learning setting and the work setting. Simulations through virtual reality can provide a real work setting context, making learning more interactive, real-time, and individualized (Blackburn-Dwyer, 2016). In addition, these platforms not only support co-learning and co-creation but also support the self-directedness of learners in information discovery, deciding ways to negotiate the learning process and manage own learning as expected in heutagogy. In an alternate way of interpretation, if a TVET system is following the approaches of pedagogy, the focus is on knowledge and skills; if following the approaches of andragogy, the focus is on competencies; if following the approaches of heutagogy, the focus is on developing capabilities (Center for Online Learning, n.d.; Halupa, 2015). Unlike other higher education environments, TVET also targets working adults with a lifelong learning framework. This demands a move towards heutagogy (Blaschke, 2012; Center for Online Learning, n.d.; Ruiz and Chabaa 2018). However, regardless of whether the underlying premise is pedagogical or andragogical, digitalization is the key for heutagogy. Still, with the appropriate enabling teaching and learning environment, selected learning principles of all three approaches (pedagogy, andragogy and heutagogy) may be incorporated into a single course to provide optimal learning experience and learner engagement (Blaschke, 2012; Halupa, 2015; Ruiz and Chabaa 2018). With digitalization, this should be evident in TVET in its approaches to theory, practice, and workplace learning, as described above. However, recent literature across regions (e.g., Gonçalves, 2019; McGrath et al., 2020; Oketch, 2016; TVET Academy, 2021) suggests that TVET institutions are experiencing financial shortages, which creates immense challenges in acquiring required digital infrastructure to be incorporated to teaching and learning process.

Another aspect of digital innovation is the possibility to provide access to affordable education for the masses. With the use of online platforms, which accelerated during the COVID-19 pandemic, access to affordable education can be improved. Alternatives to physical classroom settings such as massive open online courses help education institutes to provide more cost-effective, scalable, and flexible options to reach out to people with geographic barriers to access education institutions as well as to reach out to working adults and others who are willing to re-enter education but unable to attend physically due to rigidity in program offerings. However, during the disruptions in the delivery of programs due to COVID-19, UNESCO-UNEVOC International Centre for TVET (2020) reveals that countries on the high to medium technology spectrum moved their teaching and learning to online platforms. However, countries on the low to no-technology spectrum face immense difficulties due to the lack of infrastructure, and learners from these countries struggle to participate in the teaching and learning process or in most situations remain in education. This also supports the claims of Gonçalves (2019), McGrath et al. (2020), Oketch (2016) and TVET Academy (2021) that financial shortages operate as a critical factor when moving towards digital innovation.

As inputs, the quality of the teachers is also important since high-quality teachers contribute to obtaining higher-than-expected gains in student accomplishments (Hanushek, 2015). In the context of 4IR, teachers should have knowledge of 4IR technologies, must be capable of incorporating 4IR technologies into subject content, and must have capabilities to deliver the subject content using 4IR technologies. Here, reference is to three types of knowledge – content knowledge, pedagogical knowledge, and technological knowledge. Content knowledge involves knowledge of the subject matter concerned; pedagogical knowledge involves knowledge of processes, practices, and approaches of teaching and learning; technological knowledge involves knowledge of a variety of

digital technologies as well as the knowledge required to remain current and relevant in interacting with and effective use of these technologies in teaching and learning. However, recent literature on TVET institutions across regions (e.g., Butt et al., 2020; Holler et al., 2023; ILO, 2020; Mahdum et al., 2019) suggests that TVET teachers do not have requisite knowledge, especially, technological knowledge, and the requisite level of digital competencies. This situation also implies challenges in enhancing TVET teacher capabilities (e.g., Butt et al., 2020; Mahdum et al., 2019). In this regard, ILO (2020) provides ample evidence to show that TVET institutions need support to identify and map the skill requirements of TVET teachers, introduce incentive/disincentive schemes targeting skill uptake, develop opportunities via 'exchange/return to industry' initiatives for their capacity building, and ultimately to adapt to abreast of changes in higher education landscape with 4IR technologies. In addition, Amegah (2023) provides evidence for the need for continuous renewal and constant involvement of stakeholders in TVET curriculum design and redesign as well as its implementation. Further, recent literature specific to Asia and the Pacific (e.g., Butt et al., 2020; Mahdum et al., 2019; The World Bank Group, 2021) suggests the value of providing support by TVET institutions for sharing of experiences on 4IR competencies and technologies. However, UNESCO-ILO (2018, p. 8) states 'Teaching continues to be a profession of low prestige. In some places around the world, teachers are employed on precarious contracts with poor salaries and no access to professional development opportunities'. In this context, understanding the 'teacher' in TVET in 4IR is very important. With 4IR technologies, the definition of TVET teachers must be accepted with a broader scope as suggested by ILO (2020) and UNESCO-UNEVOC International Centre for TVET (2020). For example, ILO (2020, p.60) states 'positions that were typically covered by a teacher or instructor are evolving into systems that require a team of specialists (teachers, media designers, programmers, and subject matter experts) to design and deliver'. UNESCO-UNEVOC International Centre for TVET (2020) also identifies TVET teachers as 'teachers, instructors, trainers, tutors, managers, administrators, extension agents, guidance staff and others' (p.7). Hence, capacity-building avenues must be open to all relevant personnel.

2.3.2. Outputs

When outputs are taken into consideration, the most common proxy of human capital is the years of school attainment (Hanushek, 2015), which intends to provide a measure of skill differences in a country. Less-developed countries experience high returns from primary and secondary schooling while secondary schooling is found to have specific importance to rapidly growing economies such as Vietnam (ADB, 2021). Upper secondary or higher education enrolments in a country is particularly important to ensure middle-level skilled workers and TVET institutions play an important role in skill supply. Over the years, the emphasis was that developing countries do not have enough individuals acquiring upper secondary education, which impacts on realizing economic benefits (ADB, 2021). However, the years of education attainment do not provide an accurate picture of what happened in education institutions (Hanushek, 2015), which is especially important with 4IR. This highlights the importance of having measures other than the years of education attainment to evaluate education outcomes.

When finding alternate measures for the years of school attainment, work-based skills possessed by individuals ranks top. Previous studies provide evidence for attempts made to evaluate the skills of individuals and economic benefits (e.g., Dearden et al, 2004; Hanushek and Woessmann, 2008; McIntosh and Vignoles, 2001). When trainees passed-out from TVET institutions are concerned, the main output is the passed-out trainees, i.e., the number of passed-out trainees and the market relevance of skills gained by them (Brewer et al., 2010). For some time, scholars have pointed to the skill gap between trainees passed-out from TVET institutions and the labor market requirements across countries, for example, India (e.g., Agrawal, 2012; Bhattacharyya and Mitra, 2020) and South Korea (Jung, 2020). From employers' point of view, business organizations are coping with an inadequate supply of skilled individuals sufficiently equipped with the necessary 4IR competencies (Hirschi, 2018).

Further, skills possessed at the time of passing-out TVET institutions are insufficient to be survived in the employment and to be employable in the context of VUCA. 4IR technologies are making changes to skills in demand in labor markets signaling developments in the way economic outputs (products/services) are produced. Along these lines, it is also understood that the skills of the labor force must be upgraded to incorporate new technological and scientific content in production to modernize the way of operation of the economic sectors and to maintain a country's competitiveness. Therefore, in the current day, the world of work demands 4IR competencies, and being employed depends on youths' and working adults' capacity to upskill and reskill themselves. From youths and adults' point of view, they should also possess the capacity to learn and adapt to new technologies while on the job. Along with these changes, youths searching for employment opportunities and working adults searching to re-train themselves to be employable in the new employment landscape should search for program offerings that are up to date by national, regional, or global standards. From the TVET institutions point of view, UNESCO-UNEVOC International Centre for TVET (2020) urged TVET institutions to accelerate their response by making appropriate changes to program content as well as teaching and learning technologies. This will take us to the point we have started, i.e., inputs of education production.

2.3.3. Way forward

When the recent literature on TVET in Asia is taken into account, studies such as (Gonçalves, 2019; Jabarullah and Hussain, 2019; Reeve, 2016; Schröder, 2019) identify TVET as a primary contributor to ensure a country's continued economic and social development. The effects of 4IR are visible and felt on skills produced by TVET institutions rather than by traditional universities due to TVET's closeness to the labor market. First, the way work is performed is changing in several ways. First, job tasks, methods of performing job tasks, and equipment/devices and tools to be used are changing. Second, new skilled jobs, which were not available before, are being created. Third, the type of competencies that should be developed and how these competencies should be imparted are changing. Fourth, the skills to be possessed by teachers to successfully help trainees develop competencies are also changing (Schröder, 2019; UNESCO-UNEVOC International Centre for TVET, 2020). With 4IR, even though access to affordable education is improving and individuals in sufficient numbers are acquiring higher education, if subject content is not on par with 4IR expectations, those who acquire education qualifications may not realize expected wage returns to education. As a result, economies may fail in achieving expected economic and societal benefits. This comes to our argument, i.e., if youths have not passed-out from TVET institutions with 4IR competencies and if working adults are not provided with upskilling and reskilling programs, the expectations of industrial sectors to operate with 4IR technologies will be hampered and the country's attractiveness for investment will decrease – economic competitiveness will be shattered. In succinct, TVET institutions cannot cope with 4IR requirements without a bigger investment.

2.4. Differences in Education Production at TVET

A country's TVET system and its capacity to provide skilled labor are central components of the political economy. The design and development of the system of TVET could vary from country to country due to the prevailing characteristics of the market economy and labor market relations. However, the World Bank, ILO, and UNESCO over time 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 international, intergovernmental organizations also launched various initiatives to propagate the requirement of incorporating 4IR competencies into TVET program 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. Still, in the present study, we argue that TVET systems could vary markedly across countries in the way 4IR developments are addressed. 4IR technologies created in the West are both capital and skill intensive. It is

clear that 4IR technologies are more suited to the nature of economic conditions and labor market characteristics of developed countries (Bhattacharyya and Mitra, 2020). Hence, the way countries respond and adapt to 4IR developments could vary across countries, especially in the developing world. It is expected that countries face more challenges in their responses, and these could be observed at different levels, such as policy frameworks, industrial sectors, and education sectors (Jung, 2020; Persson and Hermelin, 2018; UNESCO, 2021c). Therefore, it is important to understand the differences in responding to 4IR developments by TVET institutions across countries and the implications for policymaking. Therefore, we consider the 'annual growth rate of real gross domestic product (GDP) per employed person' as an important economic indicator that could make significant differences across countries in the way they respond to 4IR requirements in their TVET program offerings.

2.4.1. Differences by Annual Growth Rate of Real GDP Per Employed Person

It is important to make a connection between the labor market and the education levels of the labor market participants from the economic indicators' standpoint. The literature such as Jongen (2004) pinpoints such a relationship by highlighting the undisputable relationship between education and training efforts by a country and its annual growth rate of real GDP per employed person. Since the introduction of the United Nations Sustainable Development Goals (SDG), this indicator has become a target for achieving one of the SDGs. Specifically, the eighth (8) goal of the SDG is on a country's ability to achieve 'sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all' (The United Nations, n.d.). The United Nations (n.d.) states that the 'annual growth rate of real GDP per employed person' is the indicator that countries must adopt to measure the achievements of 'higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high value-added and labor-intensive sectors' (SDG8 target 8.2 and indicator 8.2.1). The indicator 'annual growth rate of real GDP per employed person' conveys a country's labor productivity (The World Bank, n.d. a). Since a country's status in **'**technological upgrading/innovation and economic growth' and 'employment growth and the creation of decent work' go hand in hand we propose that a country's TVET system's response to 4IR could vary by this indicator.

3. Methodology

3.1. Sample and Data Collection

The study used a survey to collect data from 15 countries. 428 teachers engaged in delivering tertiary-level programs belonging to STEM fields responded. We approached respondents through an email database of the Colombo Plan Staff College located in Manila, Philippines. The respondents were in its email database since they have followed in-country teacher training programs conducted by the institution during the last three years. Table 1 provides country details together with the annual growth rate of real GDP per employed person as per the ADB (2020, p. 49).

Based on a country's income and region categorization of the World Bank (n.d. b), 52% came from South Asia whereas 48% came from East Asia and the Pacific; 87% came from lower-middle income countries whereas 13% came from upper-middle-income countries (i.e., Fiji, Malaysia, and Thailand). Based on the values shown in Table 1, we created two categories 'countries with less than 4% annual growth rate of real GDP per employed person' and 'countries with 4% or more annual growth rate of real GDP per employed person'. Accordingly, 53% belonged to the less than 4% group whereas 47% belonged to the 4% or more group. Respondents' characteristics are shown in Figures 1 to 3. Regarding the respondents' characteristics, 31%, 23%, and 46% were respectively attached to TVET teacher training/research institutes, Polytechnic/TVET universities, and TVET colleges. Regarding respondents' work roles, 48%, 37%, 12% and 2% were respectively from administration, academic, technical support, and academic support work roles. As the highest level of education achievement, 23% had doctorates, 49% had master's

degrees, 18% had bachelor's degrees, and 10% had certificate, diploma, or higher diploma. The mean age of the respondents was 44 (S.D. = 9.01, minimum 25, maximum 68, skewness = .06).

Table 1. Country Details.

Country	% from Total[1]	Annual Growth Rate of Real GDP Per Employed Person[2]
India	15	4.8
Bangladesh	11	5.9
Sri Lanka	10	2.5
Nepal	4	3.9
Bhutan	4	3.4
Pakistan	7	1.1
Cambodia	7	5.3
Myanmar	6	5.4
Philippines	13	3.3
Malaysia	5	2.6
Thailand	7	2.7
Mongolia	2	5.3
Vietnam	7	5.8
Fiji	1	1.7
Papua New Guinea	1	3.0

Notes: [1] = 428 (=100%); [2] = at constant 2010 US Dollar.

Based on a country's income and region categorization of the World Bank (n.d. b), 52% came from South Asia whereas 48% came from East Asia and the Pacific; 87% came from lower-middle income countries whereas 13% came from upper-middle-income countries (i.e., Fiji, Malaysia, and Thailand). Based on the values shown in Table 1, we created two categories 'countries with less than 4% annual growth rate of real GDP per employed person' and 'countries with 4% or more annual growth rate of real GDP per employed person'. Accordingly, 53% belonged to the less than 4% group whereas 47% belonged to the 4% or more group. Respondents' characteristics are shown in Figures 1 to 3. Regarding the respondents' characteristics, 31%, 23%, and 46% were respectively attached to TVET teacher training/research institutes, Polytechnic/TVET universities, and TVET colleges. Regarding respondents' work roles, 48%, 37%, 12% and 2% were respectively from administration, academic, technical support, and academic support work roles. As the highest level of education achievement, 23% had doctorates, 49% had master's degrees, 18% had bachelor's degrees, and 10% had certificate, diploma, or higher diploma. The mean age of the respondents was 44 (S.D. = 9.01, minimum 25, maximum 68, skewness = .06).

3.2. Survey Questionnaire

We evaluated the 'actions already taken' instead of 'intend to do' or 'identified as important to do'. This is in line with distinctions demarcated by UNESCO (2021a, p. 28). The study was designed 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. The content of the survey questionnaire can be divided into four broad areas as follows. The item measures of each broad area are given 'as is' in Tables 2 to 5.

- the existence of mechanisms for institutions to leverage 4IR developments
- institutions' support for the capacity development of teachers
- the incorporation of 4IR competencies into programs
- 4IR technologies in use for subject content delivery in their respective TVET institutions.

The survey questionnaire used three types of scales as follows. The respondents used these three types of Likert scales to evaluate the four broad areas under study.

- 7-point Likert scale as shown in Tables 2 to 4 (strongly agree =7, agree = 6, More or less agree = 5, moderate = 4, More or less disagree = 3, disagree = 2, strongly disagree = 1).
- 3-point Likert scale as shown in Table 2 (comprehensive and well-implemented formal system exists = 3, a formal system exists but with some gaps in implementation = 2, no such system = 1).
- 3-point Likert scale as shown in Table 5 (highly used = 3, the system exists but is rarely used = 2, no such system/not used = 1).

3.3. Methods of Data Analysis

The statistical data analysis software SPSS was used for the data analysis. Differences were analyzed by the annual growth rate of real GDP per employed person. As mentioned in the section sample, based on the values shown in Table 1, two categories were created 'countries with less than 4% annual growth rate of real GDP per employed person' and 'countries with 4% or more annual growth rate of real GDP per employed person'. Data were analyzed for significant differences using One-way ANOVA. Partial Eta Squared (partial η^2) was used to evaluate the effect size.

4. Results

Table 2 shows the results for the extent to which mechanisms exist for TVET institutions to leverage 4IR developments. Figure 1 shows the distribution of total mean values for the same. As described earlier, the data were tested for significant differences using the indicator annual growth rate of real GDP per employed person. Our proposition was that countries in the category with a higher annual growth rate of real GDP per employed person are in a better position in their responses. Regarding 'consultants advice on incorporating 4IR competencies into programs' in Table 2, countries with an annual growth rate of real GDP per employed person of 4% or more scored the highest. The difference is significant ($p < .05$). Partial η^2 value suggests that the annual growth rate of real GDP per employed person could account for 3% of the variance. The rest of Table 2 can also be interpreted in the same manner. Accordingly, significant differences can be found in three out of the four areas investigated. Therefore, the results shown in Table 2 suggest that the countries belonging to the category with the higher annual growth rate of real GDP per employed person are better equipped with mechanisms to leverage on 4IR developments than countries with the lower rate, and the differences are statistically significant.

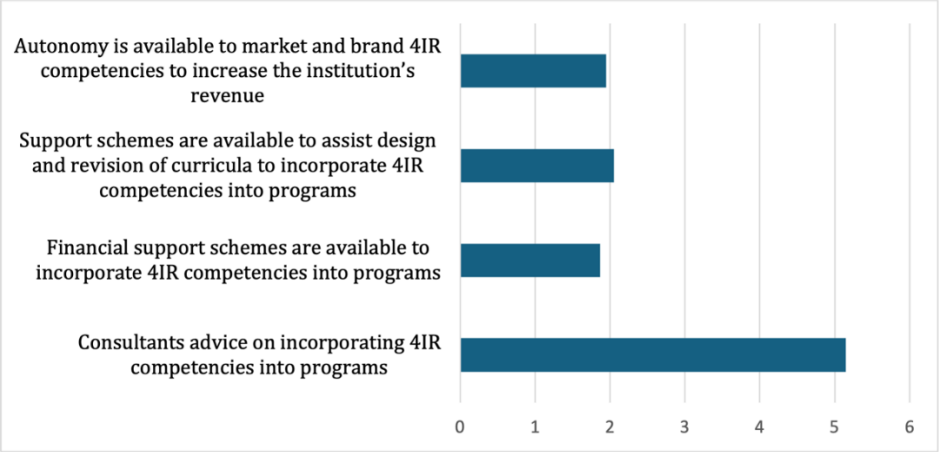

Figure 1. Distribution of Total Mean Values for the Existence of Mechanisms to Leverage on 4IR Developments
Note: Mean values range from 1 to 7.

Table 2. Existence of Mechanisms to Leverage on 4IR Developments.

	Total	Annual Growth Rate of Real GDP Per Employed Person				
		Less than 4%	4% or more	F	Sig.	Partial η^2
Consultants advice on incorporating 4IR competencies into programs±	5.15 (.12)	4.84 (.15)	5.38 (.16)	5.98	.015	.026
Financial support schemes are available to incorporate 4IR competencies into programs◇	1.87 (.05)	1.73 (.06)	2.00 (.07)	7.81	.006	.033
Support schemes are available to assist design and revision of curricula to incorporate 4IR competencies into programs◇	2.05 (.05)	2.06 (.06)	2.08 (.07)	.041	.839	.000
Autonomy is available to market and brand 4IR competencies to increase the institution's revenue◇	1.95 (.05)	1.79 (.06)	2.07 (.07)	7.69	.006	.033

Notes: Mean and standard error of the mean (SE). SE in brackets. ◇ = 3-point scale; ± = 7-point scale.

Table 3 shows the results for teacher capacities of 4IR competencies. Figure 2 shows the distribution of total mean values for the same. As described earlier, the data were tested for significant differences using the indicator annual growth rate of real GDP per employed person. Our proposition was that countries in the category with a higher annual growth rate of real GDP per employed person are in a better position in their responses. The data shown in Table 3 can be interpreted in the same manner described above for Table 2. Accordingly, the differences are significant for all aspects investigated ($p < .05$). Therefore, the results shown in Table 3 suggest that the countries belonging to the category with the higher annual growth rate of real GDP per employed person are in a better position regarding teacher capacities of 4IR competencies than countries with the lower rate, and the differences are statistically significant.

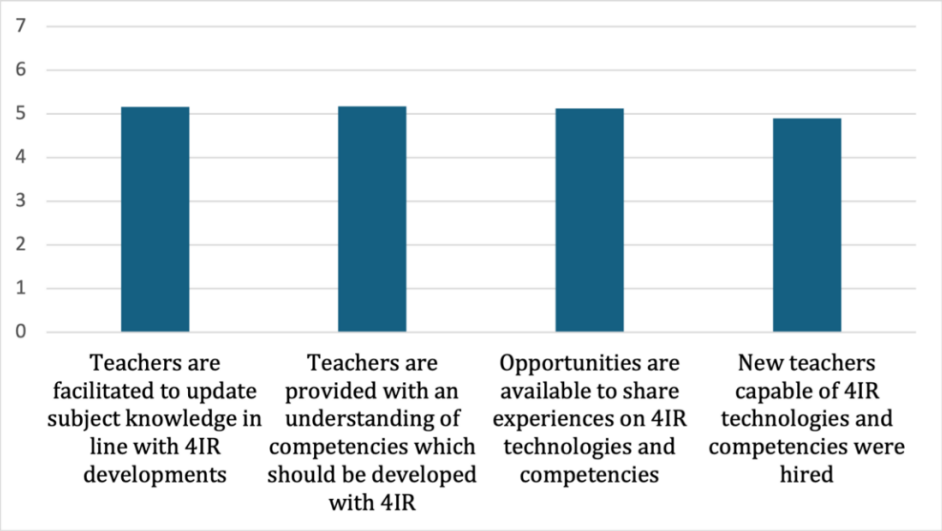

Figure 2. Distribution of Total Mean Values for Competencies of Teachers.

Notes: Mean values range from 1 to 7.

Table 3. Competencies of Teachers.

	Total	Annual Growth Rate of Real GDP Per Employed Person				
		Less than 4%	4% or more	F	Sig.	Partial η^2
Teachers are facilitated to update subject knowledge in line with 4IR developments	5.16 (.12)	4.63 (.15)	5.30 (.16)	6.88	.021	.028
Teachers are provided with an understanding of competencies which should be developed with 4IR	5.17 (.13)	5.00 (.16)	5.47 (.17)	4.55	.022	.021
Opportunities are available to share experiences on 4IR technologies and competencies	5.13 (.11)	4.88 (.14)	5.42 (.15)	6.49	.011	.028
New teachers capable of 4IR technologies and competencies were hired	4.90 (.12)	4.68 (.15)	5.17 (.16)	5.09	.025	.022

Notes: Mean and standard error of the mean (SE). SE in brackets. All in 7-point scale.

Table 4 shows the results for the extent to which 4IR competencies were incorporated into program offerings. Figure 3 shows the distribution of total mean values for the same. As described earlier, the data were tested for significant differences using the indicator annual growth rate of real GDP per employed person. Our proposition was that countries in the category with a higher annual growth rate of real GDP per employed person are in a better position in their responses. When data shown in Table 4 are interpreted in the same manner used above, significant differences exist for the two aspects investigated ($p < .05$). Therefore, the results shown in Table 4 suggest that the countries belonging to the category with the higher annual growth rate of real GDP per employed person are in a better position in incorporating 4IR competencies into program offerings than countries with the lower rate, and the differences are statistically significant.

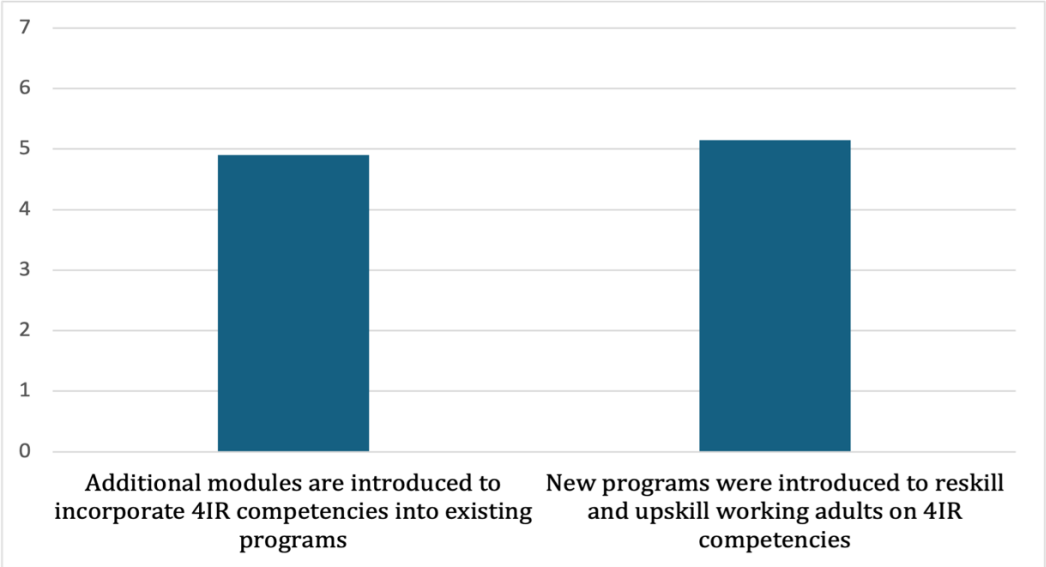

Figure 3. Distribution of Total Mean Values for Incorporation of 4IR Competencies.

Notes: Mean values range from 1 to 7.

Table 4. Incorporation of 4IR Competencies.

	Total	Annual Growth Rate of Real GDP Per Employed Person				
		Less than 4%	4% or more	F	Sig.	Partial η^2
Additional modules are introduced to incorporate 4IR competencies into existing programs	4.90 (.13)	4.38 (.16)	4.98 (.17)	5.52	.018	.017
New programs were introduced to reskill and upskill working adults on 4IR competencies	5.15 (.12)	4.82 (.15)	5.28 (.17)	4.76	.042	.016

Notes: Mean and standard error of the mean (SE). SE in brackets. All in 7-point scale.

Table 5 shows the extent to which 4IR technologies were in use for subject content delivery at TVET institutions. Figure 4 shows the distribution of total mean values for the same. As described earlier, the data were tested for significant differences using the indicator annual growth rate of real GDP per employed person. Our proposition was that countries in the category with a higher annual growth rate of real GDP per employed person are in a better position in their responses. Regarding the use of massive open online courses in Table 5, countries with an annual growth rate of real GDP per employed person of 4% or more scored the highest. The difference is significant ($p < .10$). Partial η^2 value suggests that the annual growth rate of real GDP per employed person could account for 2% of the variance. For all other 4IR technologies, the differences are not significant.

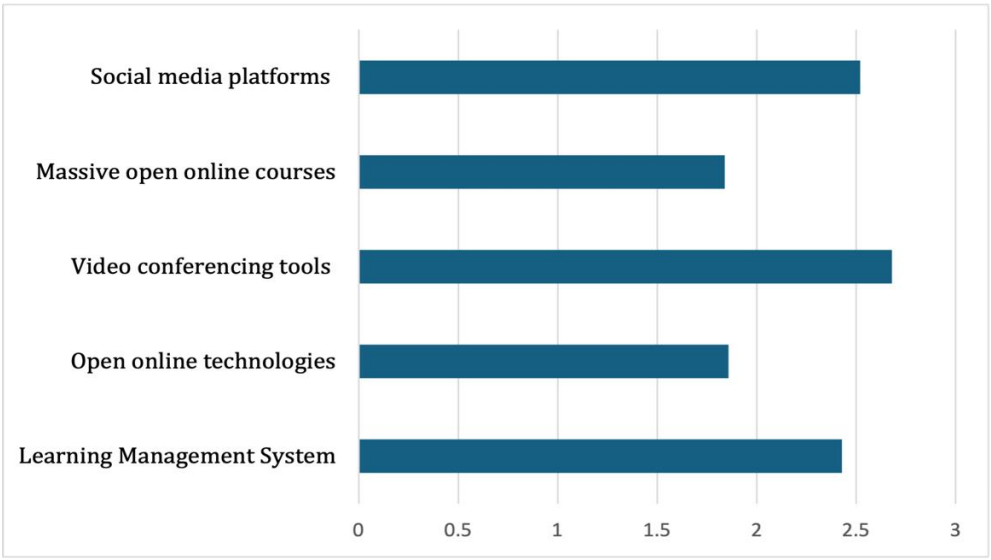

Figure 4. Distribution of Total Mean Values for the Use of Technologies for Subject Content Delivery
Note: Mean values range from 1 to 7.

Table 5. Technologies for Subject Content Delivery.

	Total	Annual Growth Rate of Real GDP Per Employed Person				
		Less than 4%	4% or more	F	Sig.	Partial η^2
Learning Management System	2.43 (.05)	2.48 (.06)	2.41 (.07)	.611	.435	.003
Open online technologies	1.86 (.06)	1.84 (.07)	1.90 (.08)	.312	.577	.001
Video conferencing tools	2.68 (.04)	2.66 (.05)	2.69 (.05)	.127	.722	.001
Massive open online courses	1.84 (.06)	1.73 (.07)	1.94 (.08)	3.87	.051	.017
Social media platforms	2.52 (.04)	2.58 (.05)	2.46 (.06)	2.19	.141	.010

Notes: Mean and standard error of the mean (SE). SE in brackets. All in 3-point scale.

5. Conclusion and Recommendations

The literature reviewed above provides ample understanding of changes occurring in the world of work due to 4IR, suggests that the future is about 4IR technologies and countries adopting these technologies for production processes will perform better, and pinpoints expectations from TVET institutions in the wake of 4IR technologies. However, the majority of publications available as of today are in the form of policy reports, consultancy reports, and single-country case studies on 4IR and higher education; these do not provide much substance to guide decision-making on what to consider when implementing 4IR competencies into program offerings, i.e., at the TEVT institution-level. The present study investigated the response for 4IR technology and competency integration into TVET program offerings. We tested the data for significant differences using the indicator annual growth rate of real GDP per employed person. SDG8's target 8.2 claims that countries with the higher annual growth rate of real GDP per employed person are better positioned to achieve 'higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high value-added and labor-intensive sectors' (The United Nations, n.d.). We argued that countries in the category with a higher annual growth rate of real GDP per employed person are in a better position in their responses to 4IR. Our results suggest that the response to 4IR by countries belonging to the category with the higher annual growth rate of real GDP per employed person is better than countries with the lower rate, and, in most areas, the differences are statistically significant. It is well known that TVET is the sector of higher education that is the closest to the labor market. TVET systems of developing countries with higher levels of economic growth rates are very responsive to industry or labor market requirements. However, it is very difficult to find the literature to back this argument. Our experience suggests that this was very much true for some developing countries, such as Bangladesh whereas some other developing countries do not find sufficient industrial structure for their TVET systems to grow, such as Nepal and Bhutan. Current developments make it clear that STEM fields are going to be prevalent and predominant in the future. Overall, the findings suggest the need for countries to have a coherent strategy to integrate TVET programs with 4IR competencies and technologies. Regarding policy recommendations, the findings guide several recommendations, which can be broadly categorized as follows. Each of these recommendations is discussed in detail in the sections to follow.

- Recommendations concerning institutional inputs
- Recommendations concerning the teacher education system at the national/regional level
- Recommendations concerning industry involvement in skill formation at TVET
- Recommendations concerning populace having an understanding of 4IR and 4IR technologies/competencies
- Recommendations concerning glocalized TVET systems across countries

5.1. Recommendations Concerning Institutional Inputs

Institutional inputs are very important in responding to 4IR requirements – curricular addressing 4IR competencies, teachers having knowledge and skills on 4IR technologies, teachers having capabilities to deliver the subject content using 4IR technologies, and institutions having infrastructure to be used in the teaching and learning process. In the process of education production at TVET, institutions should have a system to monitor existing vocations and professions it caters across economic sectors, changes to these existing vocations and professions due to changes in skills that should be possessed, and the emergence of new vocations and professions in all economic sectors. Reskilling and upskilling programs are necessary to address changes to these existing vocations and professions due to changes in skills that should be possessed; working adults will return to TVET institutions for these reskilling and upskilling programs. New programs must be introduced to address skill demands for new vocations and professions. Nevertheless, the curriculum of existing program offerings must also be updated by incorporating 4IR technologies to cater to the current active trainees enrolled with TVET institutions. It should be kept in mind that 4IR technologies could have short life cycles. This suggests that TVET institutions must remain responsive, resilient, and future-ready for any new developments concerning program offerings. TVET institutions must anticipate and continue to identify important competencies as well as the areas of reskilling and upskilling with anticipated changes to 4IR technologies, i.e., TVET institutions need to be innovative and continuously adapt digital technologies and transform to progress.

5.2. Recommendations Concerning Teacher Education System at the National/Regional Level

A diverse and sophisticated teacher education system at the national/regional level is also required. Capacities required from TVET teachers to move with technological changes play a vital deciding criterion. When TVET teacher competencies are lagging behind, it hinders a TVET institution's potential to implement 4IR competencies. TVET teachers should be provided with opportunities to continually update their competencies. Some key decisions on TVET teacher capacity development are beyond the scope at the TVET institutional level (i.e., micro level) such as developing competency frameworks for TVET teachers, incorporating 4IR competencies into national-level teacher training curricula, and introducing incentive schemes to reward competency acquisition, which are supposed to be handled at macro and meso-levels. Any other attempts to increase the responsiveness of a TVET institution to technological changes happening in the industry could enhance the institution's ability to respond to the industry's needs in its program offerings. For example, with specific reference to new hires, ILO (2020) states that TVET institutions require instructional designers, teachers, and media creators as well as assessment and skills experts for the smooth delivery of program offerings, and TVET institutions should have autonomy to hire new teachers. TVET institution's financial strength is also important in acquiring and upgrading digital infrastructure. As discussed in the next paragraph, although macro and meso-levels of TVET should play a major role in the creation of a multi-stakeholder collaboration system for TVET, at the micro level, TVET institutions can also take some actions - locally/regionally within a country that could assist in acquiring financial strength and digital infrastructure. For example, TVET institutions have a responsibility to make businesses aware of 4IR technologies

and propagate the value of implementing 4IR technologies in their production processes. Such attempts enhance and create a situation of vendor-driven implementation of 4IR competencies into program offerings.

5.3. Recommendations Concerning Industry Involvement in Skill Formation at TVET

When TVET is understood as a unique system within a higher education sector, skill formation at TVET institutions can be understood in two dimensions where one represents public commitment, i.e., government spending in TVET identifying program offerings as an alternative to academic degrees while the other represents industry involvement, i.e., industry actively involves in TVET program offerings since TVET caters for industry needs (Busemeyer and Trampusch, 2012). When TVET is perceived purely as a public commitment to provide an alternative means of higher education, there is a tendency for TVET to persistently become a small and weak system with less responsiveness to the labor market, which is difficult to upgrade despite relentless government-backed reform efforts (Carneiro et al., 2010; McGrath et al. 2020; Oketch 2016). 4IR is going to have a massive effect on economies and societies at large. In 4IR, economies may not perform better by only relying on a single economic activity or a few large players in key economic activities. All stakeholders need to work together to create a conducive context for an economy to respond effectively and grow. With 4IR, TVET must be represented by multistakeholder involvement or cross-sector engagement – the state, industry (for-profit), academia, and not-for-profit. It is important to decide the level of government involvement in TVET through public expenditures, and how to engage other stakeholders to best utilize scarce resources to harness maximum skills in people (output of TVET). For this, specific national policies must be developed. A failure of a country to establish a multistakeholder partnership will hinder the responsiveness of TVET institutions in responding to 4IR competencies. However, it is unclear in the current literature whether developing countries in general and their leaders are prepared to take on the challenges of 4IR and ready to utilize 4IR technologies and competencies to make the living standards of citizens better.

5.4. Recommendations Concerning Populace Having an Understanding of 4IR and 4IR Technologies/Competencies

In the race to move along 4IR developments, the populace having an understanding of 4IR and 4IR technologies/competencies is important. Still, these are new to many people or population groups. This is true within a country - countries may vary in their understanding of 4IR and its effect on economic sectors. Countries that have more understanding could respond much earlier and better and could seize the opportunities brought about by 4IR technologies well in advance. In the era of 4IR, higher rewards are attached to what individuals possess - knowledge and skills. As per Carneiro et al. (2010), education is an 'expensive sorting device to enable employers to identify more able individuals' from the labor market. If the populace has an understanding of what they should be capable of in 4IR in comparison to what they are capable of, they may at one point question the efficiency of education production at TVET institutions – in terms of the cost of individual investment for TVET programs, public expenditures to maintain TVET institutions, market relevance of TVET programs. With sufficient knowledge, potential students (first-time or returning working adults) could pressure governments through political processes or may look for other avenues for their capacity development. The possibility for the latter is greater since TVET is provided through market mechanisms.

5.5. Recommendations concerning glocalized TVET systems across countries.

UNESCO and other international bodies are working towards creating standardized or glocalized TVET systems across countries. Yet, our findings suggest that the level of technology and innovation in the economies'

production process (or the level of industrialization) may decide labor market demand for low to middle-level technical expertise, which in turn could impact TVET institutions' response to 4IR. Alternatively, many developing countries may identify focusing on glocalization could prepare them to better respond to the future trends in education. In particular, an important foreign revenue source for many developing countries is foreign employment; individuals with TVET qualifications/accreditations move to developed countries for employment, i.e., skill mobility at the technician level. Inter-governmental organizations (e.g., UNESCO, 2016; UNESCO-ILO, 2018) promote TVET systems to create and maintain almost indistinguishable TVET systems across countries and produce skilled personnel possessing globally acceptable or accredited qualifications. If catering for foreign employment is the agenda of certain TVET programs, the integration of 4IR competencies into programs is a way to move forward. For this, TVET institutions' inputs should be ready to generate the expected outcome – market-ready TVET-qualified/accredited skilled personnel for the foreign labor market. This has a tremendous impact on the way TVET systems should operate on a global scale with adherence to quality as well as continuous monitoring and evaluation at the level of TVET institutions.

6. Limitations and Future Research

The study has limitations, which will inspire and guide many future research avenues. First, the data were collected using a survey, and the responses were limited. However, when considering that the study was conducted purely for academic purposes without any financial support, the countries we have covered as well as the number of responses received should be appreciated. The usefulness or value of the findings will eventually be evaluated with the extent of the current availability of information on higher education institutions' response to 4IR. The number of areas investigated to describe TVET's response is also limited. An evaluation of TVET institutions' inputs is complex and data need to be gathered from different perspectives and sources; the labor market relevance of skills produced should take into account the labor market outcomes of passed-out trainees. Although the study has limitations, we expect that the findings presented in this paper provide inspiration to broaden the scope in depth and breadth in the years ahead.

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Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Author contributions

Conceptualization: G.L.D. Wickramasinghe, V. Wickramasinghe; Investigation: G.L.D. Wickramasinghe; Methodology: G.L.D. Wickramasinghe, V. Wickramasinghe; Writing – original draft: V. Wickramasinghe; Writing – review & editing: G.L.D. Wickramasinghe, V. Wickramasinghe.

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