FUTURE SKILLS IN INDUSTRY 4.0 ERA: EMPIRICAL EVIDENCE FROM OIL AND GAS COMPANIES

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ABSTRACT

Industry 4.0 is reshaping the business landscape and bringing about significant changes in many industries including the oil and gas industry. A skilled workforce is critical to the industry sustainability and competitiveness, however, the insufficient of skills are often cited as a strong barrier to Industry 4.0 implementation.

This paper aims to provide empirical evidence of the impact of oil and gas 4.0 implementation on skills requirement in the oil and gas sector. Using a questionnaire method, the data were collected from 69 experts in the oil and gas sector.

Eight structured interviews were also conducted. The questions were aimed at exploring oil and gas firms' views and experiences on the effect on technological changes on skills requirements in the oil and gas 4.0 era as well as policy implications.

The outcome of the study contributes to shed light on future skill needs linked to oil and gas 4.o in order to inform curriculum development and training programs in education institutions in a developing economy and provide an input for government and related stakeholders for planning and policy-making purposes.

INTRODUCTION

The term Industry 4.0 was first introduced in 2011 in Germany to describe the connection between the real and the virtual world which is known as cyber-physical production systems (Drath & Horch, 2014). The increased use of connectivity is increasingly blurring the line between the two words. Industry 4.0 is not the result of one technology, but the results of the combination of multiple technologies, including big data, blockchain, industrial internet of things (IIoT), autonomous robot, digital twin, cloud computing, 3D printing, augmented reality, and cybersecurity (Kadir, 2017).

The term Oil and Gas 4.0 (hereafter named OG 4.0) was introduced for the first time at the Abu Dhabi International Petroleum Exhibition and Conference (ADIPEC) in 2018. Through OG, 4.0 O&G firms attempt to seize the opportunities created by Industry 4.0. The main of objective of OG 4.0 is to allow the industry to remain competitive and resilient regardless of the oil prices the fluctuation (The National, 2018).

The use of industry 4.0 technologies in the O&G sector is expected to increase operational efficiency and reduce maintenance costs through preventive and predictive analytics to maintain a competitive advantage in the face of oil price volatility, energy demand fluctuation, and the pressing need to shift to cleaner energy business models. Although O&G 4.0 is gaining interest by O&G firms, there are still some challenges which need to be addressed in order to achieve its full potential. The Covid-19 pandemic outbreak has significantly accelerated the use of new technologies in many industries including O&G industry. OG 4. 0 implementation is expected to open up more and more opportunities for remote operations and maintenance.

Historically, all past technology did not only change businesses and industries, but also changed many job functions and professions. Industry 4.0 revolution is no exception. As a result, the requirements for the workforce with regards to their knowledge and skills will also change. Some job tasks will be realigned or expanded to include additional skills, while other tasks will be replaced with new ones, and thus the skills related to the obsolete tasks will

become redundant. In addition, the future skills are not only impacted by technology, but by other factors such as the green economy.

Skills are critical for individual employability as well as economic competitiveness. However, the lack of talent and skills gap were cited to be amongst the main challenges to OG 4.0 implementation (Benayoune, et al., 2020; Tung et al., 2020; Mogos et al., 2019; Zihifeng, 2019). Due this ongoing technological change, providing graduates and workers with the right skills is a critical factor for smooth transition to OG 4.0 era. Through literature review, survey and structured interviews, the study aims at exploring OG 4.0 impact on skills requirement, highlight most in-demand skills and identifying how O&G firms are addressing their digital skills needs as well as policy implications. It is worth noting that the literature review, the survey and interviews are a part of a project entitled "The Future of Labour Market in the Energy Sector: Challenges and Opportunities", which addresses several OG 4.0 related issues. Only those questions that are relevant to the scope of this paper are discussed.

To achieve the objectives of this study, the paper is structured as follows: Section 3 gives an overview of existing literature. The research methodology is presented in Section 2. Survey and interview results are discussed in Section 4. Policy response is presented in section 5. Conclusions and recommendations are presented in section 6.

LITERATURE REVIEW

This literature review was a part of a project entitled "The Future of Labor Market in the Energy Sector: Challenges and Opportunities", which addresses several OG 4.0 and Industry 4.0 related issues. Only the literature that is relevant to the objectives of this paper are presented.

Effect of OG 4.0 on Jobs

Historically, all past technology did not only change the way business is being conducted and industries, but also changed many job functions and professions. Industry 4.0 is no different. Many recent studies explored how the technology is changing jobs (PetroLMI, 2018; PwC, 2017; Lamb, 2016; Arntz et al., 2016). The focus, however, was on the jobs at risk of being automated. It is important to identify the jobs at high risk of being displaced and the emerging jobs because the change in employment landscape has a direct effect on skills requirements.

In O&G sector, Lamb (2016) reported that the top occupations at high risk of proportion of tasks that can be automated in the O&G sector include welders (95% probability), geological technologist (91% probability), power engineers and power system operators (90% probability), heavy equipment operators (89% probability), drillers and service operators (77%) and welding trades workers (67%). While there is potential for some jobs to disappear, it is more likely that jobs will change; some so substantially that they will no longer be recognizable, others minimally. At the same time, new types of jobs will be generated which may necessitate new type of skills. For example, field workers will be expected to have both mechanical and digital skills (PetroLMI, 2018).

Similarly, UKCS (2018) study reported that numerous occupations will be impacted by automation and digitalization in the oil and gas sector. According to the report occupational groups at high risk of being impacted in the O&G sector are data management (60% probability), administration and support (50% probability), logistics (50% probability) and drilling (50% probability). While the job families that are at low risk are engineering, management, business development and marketing. Based on their projections there will be a demand for a new generation of professionals skilled in areas such as data science & engineering, data Analytics & management, data systems & governance security, artificial intelligence, remote operations and robotics. As more and more equipment becomes connected, more data scientists will be needed to produce systems to interpret this. Data security concerns will also increase, creating demand for digital security specialists to protect data and processes. According to PetroLMI (2018), there will be an increased need for software engineers, data

management and analytics specialists and instrumentation technologists to measure operations in real-time.

Based on their study of the future labor market in the energy sector in Oman, Benayoune, et al., (2020) reported that most in-demand or emerging jobs in O&G firms in the next 5 to 10 years include data scientist/analyst, information security analyst/cyber security analyst, process automation expert, AI and machine learning specialist, robotics engineer, data architect, digital marketing specialist, android/IOS app developer, cloud architect and drone operator. However, based on their report, occupations most at risk are those frequently linked to repetitive, manual tasks that can be replaced by automation and digitalization. As a consequence, the top occupations at high risk are drillers, plant operators, power system operators, mechanical technician, welders and machine operators. However, engineering occupations such as civil, electronics, chemical engineering will remain stable in the next ten years.

The higher the percentage of manual, repetitive tasks a job consists of, the higher the change that the role will be impacted. For instance, drillers and operators are susceptible to being displaced. In O&G industry, the occupations that will experience a greater change greater highly impacted are at the operations level.

Effect of OG 4.0 on Skills

The volatility of oil price, spending cuts and mass layoffs have negatively impacted O&G firms' reputation. In addition, knowledge loss gained through years of experience due to retirement possess an additional risk for O&G firms. As demand gradually returns and oil prices increases, employment is expected to rise. As a result, attracting talent while tackling the concern of the aging workforce will be a challenge for the industry. Therefore, skills deficiency is expected in the foreseeable future. In addition, the increasing adoption of technology is not only changing occupations, but also changing the requirements for workforce skills. Many of the traditional low-skilled repetitive, low-value tasks linked to the industry in the past have now been automated. Literature suggests that demand for physical and manual skills together with necessary cognitive skills are expected to decrease, while demand for all other skills in higher cognitive and technological job specific skills are expected to increase (Ellingrud et al., 2020; Bakhshi et al., 2017; Lamb, 2016). OG 4.0, therefore, will result in considerable changes in the workforce's skills requirements. Gudanowska (2018) pointed out that although the skills required may differ in different fields, there are common and similarities the skills needed in different industries.

However, the lack of appropriate skills and skills has been highlighted as common barriers to Industry 4.0 adoption in the literature (Zhifeng et al., 2019; Lu et al., 2019; Mogos Tung & Benayoune, 2020). The insufficient technological knowledge and expertise to conduct Industry 4.0 projects is equally challenging (Tung et al., 2020). There is much discussion in Oman that graduates do not have the skills needed to participate productively in the marketplace. Oman is not alone in terms of experiencing skills mismatches and skills gap. Numerous international and European reports have identified similar outcomes within Europe and elsewhere including Canada and the USA (Brunello & Wruuck, 2019; Benayoune, 2016; EY, 2014).

To keep pace with OG 4.0 and technological change, digital and technological skills are increasing in demand all levels in all industries. Among the digital skills identified by the Singapore's Economic Development Board of emerging skill needs for Singapore's Energy, Chemicals and Utility Industries include Analysis of Data and Trends, Automation Management, IoT Infrastructure Engineering and Design, Industrial Cybersecurity Management, Big Data Management, Simulation and Modelling, Programming, IoT Infrastructure Engineering and Design (Accenture Consulting, 2017).

With more drilling rigs automated, there is an increased demand for skills to manage equipment, maintain, update and repair automation systems at remote well sites. Demand for workers with skills in software development, sensor installation and maintenance, and IT

infrastructure development and maintenance is growing as several exploration and production companies outsource automated well site monitoring and optimization systems to O&G service companies (PetroLMI, 2019). Workers will need such skills to enable them to stay relevant and employable.

Various research highlighted the importance of Science, Technology, Engineering and Mathematics (STEM) as critical for the future of jobs will be in demand (Bonfield, 2020; Maisiri et al., 2019; PwC, 2018; Bakhshi et al., 2017).

Skills that cannot easily be replaced by technology are also highlighted in the literature. These includes information technology, interpersonal skills, higher-order cognitive skills (Maisiri et al., 2019; Bakhshi et al., 2017). Bakhshi, et al., (2019) pointed out that there is a strong relationship between higher-order cognitive skills and future occupational demand.

Various studies highlighted the importance of lifelong learning (Yuen, 2018; Daling et al., 2018; Azmi et al., 2018). Yuen (2018) argued that the concept of learning at school and applying at workplace is no longer sustainable as continuous learning and reskilling will be a way of life at work. Table 1 summaries the Industry 4.0 skills based on previous studies.

Table 1		
INDUSTRY 4.0 SKILLS BASED ON PREVIOUS STUDIES		
COMPETNCY	DESCRIPTION	SOURCE
Digital and technological skills	Automation Management	PetroLMI (2019); Accenture Consulting, (2017)
	Simulation and Modelling	Jeganathan, et al., (2018); Pinol, et al., (2017); Accenture Consulting (2017)
	IoT Infrastructure Engineering and Design	Accenture Consulting (2017)
	Ability to apply, use and work with industry 4.0 technologies such as Internet of Things, additive manufacturing, robots etc.	PetroLMI (2019); Pinol, et al., (2017)
	Coding and programming	PetroLMI (2019); AISC (2018); IBSA Manufacturing (2017); Kazancoglu & Ozkan-Ozen (2018); Karre, et al., (2017); Accenture Consulting (2017).
	Development and use of robotics and automation technologies	PetroLMI (2019); AISC (2018)
	Cloud computing *i.e.,* maintaining databases and managing networks.	AISC (2018); Jeganathan, et al., (2018)
	(big) data analytic/diagnostic	Jeganathan, et al., (2018); IBSA Manufacturing (2017); Accenture Consulting (2017); Karre, et al., (2017).
	Analyse and respond to data provided by machines in the workplace	IBSA Manufacturing (2017)
	Cybersecurity and industrial cybersecurity management	Jeganathan, et al., (2018); Kazancoglu & Ozkan-Ozen (2018); Karre, et al., (2017); Accenture Consulting (2017)
	Information Technology knowledge and abilities	Jeganathan, et al., (2018); Karre, et al., (2017); Paschou, et al., (2018)
	Artificial intelligence	Jeganathan, et al., (2018)
Individual and social Skills (soft skills)	Creativity and innovation	Jeganathan, et al., (2018); Dos Santos, et al., (2018); Grzybowska & Łupicka (2017); Torii & O'Connell (2017)
	Critical thinking	WEF (2020); Dos Santos, et al., (2018); Torii & O'Connell (2017)
	Flexibility and adaptability	Daling, et al., (2018); Jeganathan, et al., (2018); Karre, et al., (2017); Pinol, et al.,

		(2017);
	Problem solving	WEF (2020); Jeganathan, et al., (2018); Gratton & Scott (2016); Dos Santos, et al., (2018); Dos Santos, et al., (2018)
	Communication	Daling, et al., (2018); Jeganathan, et al., (2018); Torii & O'Connell (2017); Pinol, et al., (2017); Oliver, et al., (2018); Gratton & Scott (2016)
	Interdisciplinary skills	Lu, et al., (2019); Daling, et al., (2018); Kazancoglu & Ozkan-Ozen (2018); Karre, et al., (2017)
	Lifelong learning	Yuen (2018); Daling, et al., (2018); Azmi, et al., (2018)
	Entrepreneurship	WEF (2020); Azmi, et al., (2018); Grzybowska & Łupicka (2017)
	Self-awareness	Oliver, et al., 2018; Kazancoglu & Ozkan-Ozen (2018); Karre, et al., (2017)
	Teamwork and collaboration	Dos Santos, et al., (2018); Oliver, et al., (2018); Jeganathan, et al., (2018); Daling, et al., (2018); Karre, et al., (2017)
	Accountability and social responsibility	Jeganathan, et al., (2018); Karre, et al., (2017)
	Leadership	WEF (2020); Azmi, et al., (2018); Pinol, et al., (2017)

Implication for Education and Training

If the skills gap is left unaddressed, it would limit the ability of O&G firms to compete and innovate. This challenge will require upskilling or reskilling the current workforce. Upskilling means workers acquire new skills to perform their current roles, whereas reskilling means workers need to gain new skills and capabilities to take on different or entirely new roles (Ellingrud et al., 2020). The changes in skills requirement will also impact the education and training system (Maisiri et al., 2019).

Opportunities to upskill or reskill can take a range of forms including on the job training, short courses, industry certification and formal education and training programs. Some of the key strategies to address technological changes in skills highlighted include, hiring new staff with skills relevant to new technologies, re-skilling existing employees or outsourcing some business functions to external contractors (WEF, 2017).

The potential change of job functions will cause the necessity of reskilling and lifelong learning to equip workers with the skills needed for OG 4.0 to participate productively in the workplace. This can be achieved by providing modular training options, personalized learning and training delivered outside of working hours or online courses. The importance of apprenticeships or work-based learning has been highlighted in the literature. Various studies pointed out the importance of lifelong learning to prepare for the future of work (Bakhshi et al., 2017; Maisiri et al., 2019; Ehlers & Kellermann, 2109).

The common challenges for Oman and other GCC countries across all sectors include the inability of the education and training providers to meet industry needs. There is also a mismatches between the supply of and the demand for skills coupled with weakness in Technical and Vocational Training (TVE) programs and the lack of lifelong learning opportunities (EY, 2014; Benayoune, 2016). To minimize the potential negative impacts of OG 4.0 on skills requirements, these challenges need to be addressed first.

Many worldwide countries are making changes to their education and training systems to respond to technological change. For instance, IBSA report (2018) cited (Re-Imagining Work: Work 4.0, 2017) that Germany is planning to change its education and vocational training

system to assist businesses and individuals to adapt and continue to adapt, to Industry 4.0 by introducing new training formats including greater use of both blended learning and work-integrated learning. The same report indicated that lifelong learning is expected to play a significant role in the future. The report also stated that incentives will be made available to low-skilled and semi-skilled workers to undertake vocational training and gain the right qualifications and skills.

SkillsFuture Singapore has partnered with various government agencies, education and training providers, industry associations and employers across different sectors to develop the Future Skills Frameworks. The Frameworks provides information about the industry, occupations and skills, along with training programs (SkillsFuture Singapore, 2021). This was followed by the development of a portal called MySkillsFuture. This portal brings together courses and modules into one platform and covers all industries to support people acquire in-demand and emerging skills across sectors. The courses were developed in collaboration with industry and Institute of Higher Learning. Some of the specific courses related to Industry 4.0 learner may take include IoT technology innovation, technologies behind Industry 4.0 and digital manufacturing and business for Industry 4.0 (MySkillsFuture, 2021). This initiative is still new, therefore, it is hard to evaluate its impact and effectiveness.

METHODS

The research method adopted is considered as an exploratory in nature. It employed qualitative and quantitative approaches to help achieving the objectives of the study. It is worth noting that the survey and interviews were a part of a project entitled "The Future of Labour Market in the Energy Sector: Challenges and Opportunities", which addresses several OG 4.0 and Industry 4.0 related issues.

Data Collection

For collecting primary data, a questionnaire and structured interviews were used. The questionnaire was prepared in Microsoft Forms and a link was sent to each respondent by e-mail. It was directed to managers and technology experts who should have sufficient expertise and knowledge about digital strategy in their firms.

Eight interviews were also conducted with selected managers and technology experts from selected O&G firms to gain more insight related to the issues being investigated. The secondary data was collected via relevant academic sources and industrial reports presented in section 2.

Sampling Method

To effectively collect data without any bias, employing a probability or random sampling was selected for this study. Random sampling is considered the easiest way of sampling technique. It gives every respondent an opportunity to be selected. The questionnaire was sent to 400 O&G companies' members of Oman Society for Petroleum Services (OPAL). The response rate was 17.25%. About 52% of participating companies were upstream (exploration and Production), 10% midstream (transportation, pipeline, oil tanker or trucks). 7% of companies were from Downstream segment as shown in Fig 1.

The data collected have been analyzed using frequency analysis techniques using Microsoft Excel and Excel Data Analysis.
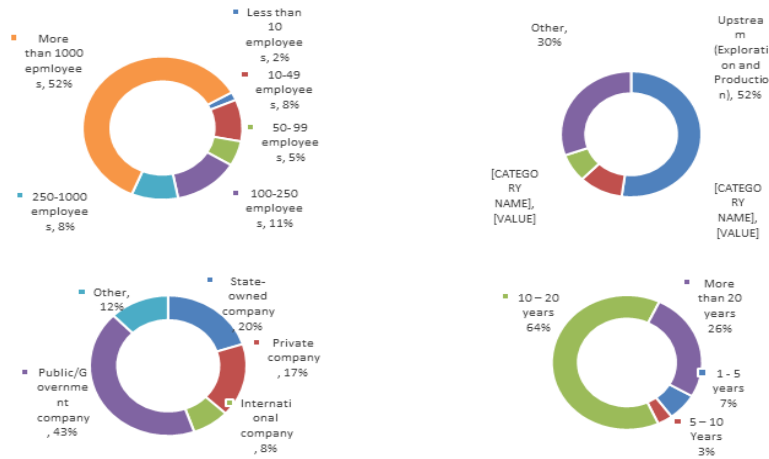
FIGURE 1
DETAILS OF PARTICIPATING COMPANIES
FINDINGS

This section presents and discusses the results of the survey considering earlier research literature together with interview data.

When asked about the impacts of OG 4.0 that will have on the workforce in the next five to 10 years, 44% of respondents indicated that new skills are required, while 30% of them said that it will reduce the number of staff and 'new team required' (20%) as shown in Figure 2a. Interview answers indicated that Industry 4.0 will increase efficiency and boost productivity, rather than pure job replacement.

(a) Impact on the workforce   (b) Education level most impacted by OG 4.0

FIGURE 2
IMPACT OF OG 4.0 IMPLEMENTATION ON THE WORKFORCE AND
EDUCATION LEVEL

47% of respondents indicated that skill-levels that will be most impacted by job losses is lower skill (high school and less). The survey-results were found to be in line with the literature. The change will most impact those with lower levels of educational attainment and in low-skilled occupations as shown in (Figure 2b).

According to respondents, the skills that will be increasingly important in O&G firms in Oman in the next 5-10 years include, data analytics (90.5%), data management and security (95%), industrial cybersecurity management (80.9%), IIoT infrastructure management (79.1%), and programming & coding and ICT (65.1%). There is growing evidence in the literature that science, technology, engineering and mathematics (STEM) will be increasingly in demand as it enables and empowers individuals to participate in the jobs of today and the future as shown in Fig. 3. In their paper (Knight & Bennet, 2019) reported that Australia's future would rely on science, technology, engineering and mathematics (STEM) disciplines at the core of innovation. STEM skills were described as the lifeblood of emerging industries. However, based on

interview data, O&G firms does not always know what skills they need, and more importantly what skills will be needed. It was hard for them to anticipate what is ahead of them.
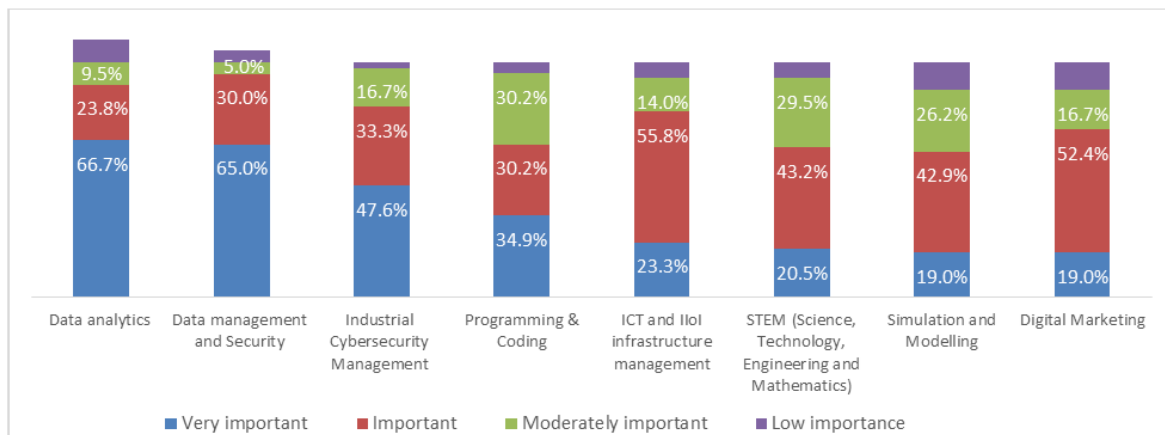

FIGURE 3
EMERGING SKILLS THAT WILL BE INCREASINGLY IMPORTANT IN THE NEXT 10 YEARS IN O&G FIRMS IN OMAN

As the future of work is based mainly on non-routine tasks, the need for soft skills such as creativity, problem-solving and critical thinking will be in demand. The most important skills identified by our respondents in order of their importance were creativity and innovation (90.5%), critical thinking (90.9%), problem solving (88.6%), communication (90,7%), flexibility and adaptability (88.6%), collaboration and teamwork (84,4%), project management (86.7%), and entrepreneurial skills (84.1%) and finally lifelong learning (72.7%). These skills remain imperative for workers to develop and maintain as they help them upskill and reskill for future jobs. This type of skills should be incorporated in curricula across all levels of the education system. These skills have been already highlighted in the literature. Opposite to our expectation, lifelong learning score relatively low (72.7%).
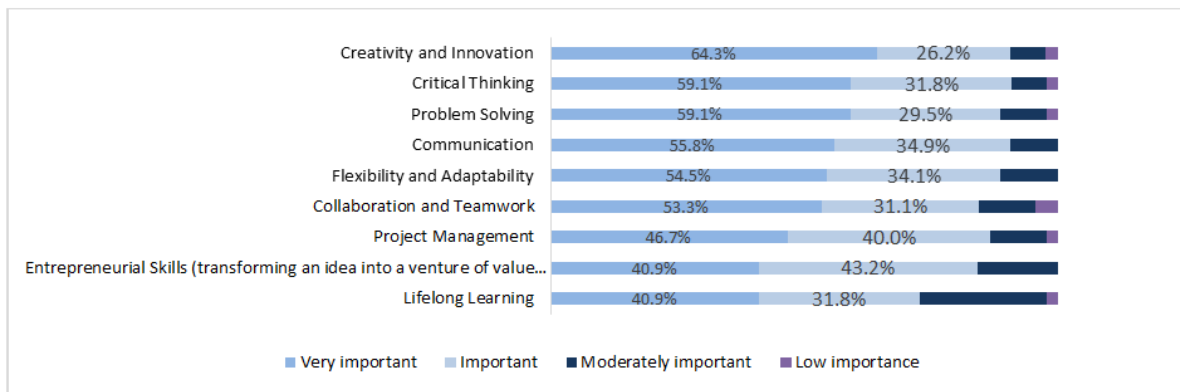

FIGURE 4
EMERGING SKILLS THAT WILL BE INCREASINGLY IMPORTANT IN THE NEXT 10 YEARS IN O&G COMPANIES IN OMAN

The majority (54%) of respondents indicated that education system do not produce graduates with the right skills to fill their current and future roles. According to respondents, the top skills (technical and Soft skills) that are currently lacking in the local marketplace in Oman are data analytics (49%), critical thinking (36%), programming and coding (36%), data management and security (36%), entrepreneurial skills (transforming an idea into a venture of

value creation for market) (36%), simulation and modelling (32%), and creativity and innovation as shown in Fig. 5. The interview answers confirmed the survey results.

In comparison, the interview answers related to the main drivers of skills gap suggested that there is mismatch between O&G needs and education output. Interview answers suggested that the education system needs to address skills anticipation. As demand for OG 4.0 technologies grows, the gap between talent supply and demand is expected to widen. The lack of awareness in the sector related to future jobs, emerging technologies, price volatility and reputation of the industry are also driving the skills gap in the sector. According to interview answers, the impact of skills gaps may affect business planning and hinder OG 4.0 implementation. However, Areas of disagreement include the extent and speed of the impact of OG 4.0 implementation on jobs and skills. Opinions are divided on whether technological changes will have minimal impact on jobs and skills or have significant disruption. Their argument is that OG 4.0 technologies is not mature enough. Technological change, therefore, is not seen as a threat (in the short-term) but it is an opportunity to improve job quality and employee satisfaction. For others, technological changes will have disruptive impact on skills requirements. However, there is an overwhelming consensus that skills development is critical for driving innovation in the industry.
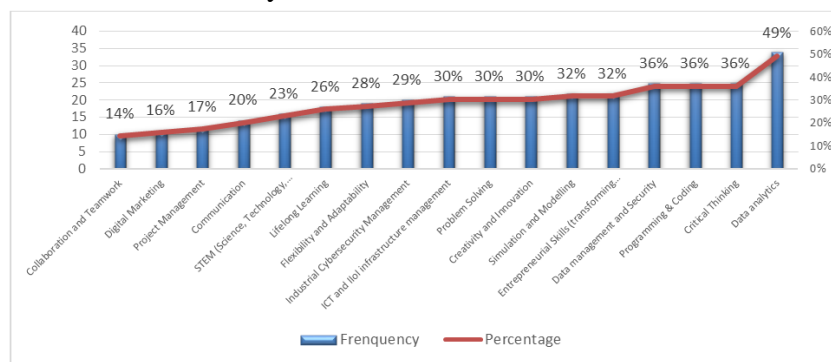

FIGURE 5
SKILLS LACKING IN THE LOCAL MARKETPLACE IN OMAN

O&G firm use various strategies to address digital skills requirements. When asked about strategies to address the digital gap, the majority of respondents (57%) indicated that they build skills internally by re-skilling existing employees to meet new job requirements or 'outsourcing some business functions to external contractors; (37%) (Figure 6a). They also cited (33%) 'increasing automation' as a means to close the skills gap or 'hiring new staff with skills relevant to new technologies' (31%). On the other hand, when asked about the main barriers tackle the skills issue, 38% of respondents identified lack of funds as a key barrier, where 36% highlighted the lack appropriate training. Unawareness of relevant skills and the lack of a clear understanding of the impact of OG 4.0 on skills were also identified as strong barrier to upskilling or re-skilling current workers (Figure 6b). As reskilling and upskilling requires an ongoing cost, the majority of respondents (48%) agree that all stakeholders (government, employer and individual) should share this cost, with 22% of respondents of the opinion that the employer who should shoulder this responsibility. Only 7% of respondents believe that workers should take part of cost. Interviews answers suggested that reskilling, upskilling and skill development is a shared responsibility of government, employer and individual worker (Figure 6c).
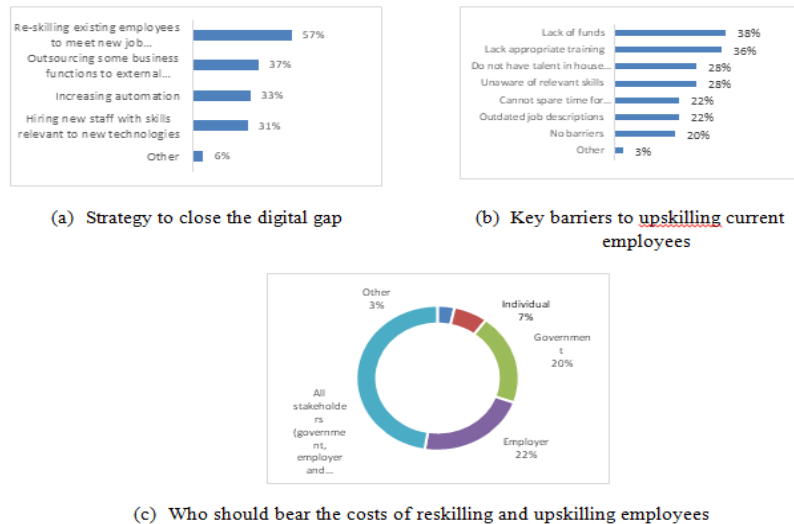
(a) Strategy to close the digital gap

(b) Key barriers to upskilling current employees

(c) Who should bear the costs of reskilling and upskilling employees

FIGURE 6
O&G SKILLS DEVELOPMENT CHALLENGES

The interviews responses indicated that the lack of job-relevant training and outdated curricula coupled with the lack of technical and soft skills are key challenges in O&G firms in Oman. The lack of information on the types of future skills the industry needs was also pointed out. The lack of lifelong learning programmers to support up-skilling also add to the skills challenges.

POLICY RESPONSE

Connecting the industry and education institutions to collaboratively plan for training and education future workers is a continuous challenge, especially for job roles that are changing. As discussed in section 4, the majority of respondents indicated that there is a poor alignment between academia and business needs. Based on interview answers, education and vocational training are required to review their programs and offering to remain relevant.

The lack of lifelong learning opportunities was also highlighted. Education institutions can look for ways to integrate lifelong learning skills into their curricula to meet the current and future skills requirement. Therefore, the government's approach to education will have a significant impact on addressing skills requirement. For instance, lifelong learning should be made available for the entire workforce, whether outside work or in the workplace as it could help ensure that workers impacted by Industry 4.0 have the right skills to remain employable. Therefore, lifelong learning opportunities as well as workplace learning, including on-the-job training should be incorporated into the education and skills development policies. Education and vocational institutions should use of massive open online courses and promote interdisciplinary training as well as integrate augmented reality technologies to develop skills required in Industry 4.0.

When asked about the role of government to support the transition towards OG 4.0, interview answers suggested that the government should develop future skills framework which provide industry-relevant information related to O&G occupations and training. The government is also expected to play the lead role in supporting industry-academia-government collaboration (Benayoune et al., 2020).

Interview answers indicated that there are few government-industry-academia collaborations in this direction. One of the industry-government driven initiative highlighted is the creation of virtual collaborative platform to promote industry-academia collaboration. This virtual platform acts as an enabler that connects academic research and know-how to industry needs, and vice versa while, at the same time, allows industry, academia and government to interact and engage in energy-related research and innovation activities.

It is worth noting that the Ministry of Higher Education, Research and Innovation (MOHERI) in collaboration with the industry and academia have launched recently an initiative called "Eidaad". The aim of this initiative is to align academia output to the industry needs by up-skilling students with future skills and applied technical skills prior to graduation through a full academic year blended internship program. However, both initiatives are still in their infancy. It is too early to evaluate their impact and effectiveness.

To bridge the current and future skills gap and transit to OG 4.0 era, Oman has no option but to invest in skills development and capacity building in education and vocation training. The education system needs to be more responsive and flexible in delivering skills in line with industry practice and future needs. This change should be aligned with the national digital strategy, Oman 2030, which aims at benefiting from the technological changes driven by the Industry 4.0 by building digital skills and capabilities *via* embedding technology in education curriculum (e.Oman, 2030). As the change in skills will most impact those with lower levels of educational attainment, vocational training will play a critical role.

CONCLUSIONS

This study evaluated and assessed the views and perceptions of senior managers and experts in oil and gas firms in Oman on the impact of OG 4.0 implementation on skills requirements.

The study results indicate that the impacts of OG 4.0 that will have on the workforce in the next five to 10 years will involve new skills with few jobs will be displaced. The skill-levels that will be most impacted by job losses is lower skill (high school and less). Therefore, the change will most impact those with lower levels of educational attainment and in low-skilled occupations. Based on the questionnaire results and interview responses, skills requirements across all O&G segments consist of two main types of skills (1) digital and technological skills which include data analytics, data management, data management and security as well as industrial cybersecurity management, IIoT infrastructure management, and programming & coding and (2) individual and social Skills which include creativity and innovation, critical thinking, problem solving, communication, flexibility and adaptability, collaboration and teamwork and lifelong learning.

It should be noted that job-specific skills related to oil and gas industry will remain important.

The majority of respondents indicated that education system do not produce graduates with the right skills to fill their current and future roles. The top skills (technical and soft skills) that are currently lacking in the local marketplace in Oman are data analytics, critical thinking, programming and coding, data management and security, entrepreneurship (transforming an idea into a venture of value creation for market), simulation and modelling, and creativity and innovation

Interview answers suggested that the education system needs to address current and future skills requirement. As demand for OG 4.0 technologies grows, the gap between talent supply and demand is expected to widen. The skills gap in the sector is also driven by the lack of awareness in the sector related to future jobs and emerging technologies together with price volatility and reputation of the industry. The impact of skills gaps may affect business planning and hinder OG 4.0 implementation in O&G firms.

Lifelong learning should be made available for the entire workforce as it could help ensure that workers impacted by Industry 4.0 have the right skills to remain productive in the labor market.

To support the transition towards OG 4.0, O&G firms expect the government and related stakeholders to anticipate emerging skills needs and adapting its policies accordingly as well as play the lead role in supporting industry-academia-government collaboration. Besides including technical and no-technical skills in curricula, lifelong learning opportunities should be

incorporated into the education policies. There is a need for all stakeholders to collaborate to develop a future-ready workforce.

The paper presents additional and data to fill a gap in the academic research in this field. It contributes to the current knowledge base of skills requirement in industry 4.0 in the O&G industry in Oman. Nevertheless, the data of this study was based on answers from a single or two respondents from each O&G firms. The respondents may not have knowledge about all the research themes. This can be considered as a limitation. Therefore, future research can draw data from multiple respondents from the same firm to further investigate this topic and strengthen the results. The second limitation is that the respondents came all from O&G firms in Oman. Hence, findings are only generalizable within the context of Oman. Future research may further investigate skills requirements and issues and obstacles related to access to skills development in other sectors and contexts. However, the author believes that results of this study are also applicable to other industries in developing economies as the outcome of the study is in line with the literature in terms of skills requirements and development needs.

ACKNOWLEDGEMENTS

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