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Blockchain-based human resource management practices for mitigating skills and competencies gap in workforce

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Abstract

Skills gap between company needs and competencies occupied by the workforce can be the source of inefficiencies. The purpose of this research is to develop a blockchain-based human resource (HR) framework to match the needs from the company and workforce competencies This framework will help Corporate Training Centre to standardized the competencies which then used by HR Department to develop the training material. In order to get valid information regarding skills that are needed from the company, we develop a prototype based on Blockchain. Hence, blockchain-based HRM is built to improve the quality of workforce competency in an organization. The current organizations are struggling to fulfil the needs of the workforce in accordance with industry quality standards. Therefore, this will help all parties to create a consensus between the needs of the industry with the labour market. Corporate Training Centre through the competent institution will be the mediator or intermediary to unite the information from companies, training institutions, and Professional Certification Institutions. As a result, in the long term, the needs of the workforce with the qualification required by the company in such industries will always fit the current situation. Blockchain helps to process the information and data needed by each party so that the connection between parties will be assisted efficiently and effectively.

Keywords

Blockchain, human resource management, employee skills shortage, consensus

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Introduction

The fourth industrial revolution (IR 4.0) aims to disrupt the business models in various sectors, such as manufacturing, mining, fashion and so forth, with the use of digital technologies. The examples of digital technologies used in industry 4.0 era are sensor technologies, artificial intelligence, robotics, etc.[1] For maximum business efficiencies and benefits, industry 4.0 requires workforce who have skill to use the relevant frontier technologies. A big issue in facing the adoption of Industry 4.0, across a number of countries and sectors, is the lack of appropriate skills in the workforce.[2,3] This lack of appropriate skills is coming from many causes, for example, there is no coordination between training department, lack of supervision from Corporate Training Centre and lack of communication between industry players and their networks (universities or high school as workforce supplier).

High competencies and skilled workforce can be seen as a determination of good quality product and service.[4] Such efforts to improve product quality and the competitiveness

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of products have been done in many ways. However, it is very limited or there has not even been an attempt to think that a good product comes from the quality of knowledge possessed by competent and standardized human resources and the collaboration model among them. Therefore, developing workforce competency standardization in a given industrial field that is aligned with the expectations and requirements of that sector is a pressing problem.

To address the lack of knowledge or skills gaps in the Industry 4.0 economy, various organizations and individuals make use of micro-credentials from the relevant training bodies. However, the lack of any agreed standards regarding the competencies or skills in each of the micro-credentials means that there is no uniformity or agreement in the skills imparted by different training provider. This results in the situation wherein the imparted skills by the training providers do not meet the job requirements in Industry 4.0. It also leads to a scenario wherein the skills of the persons trained would vary from one training provider to another. Finally, this results in a vicious economic circle of high unemployment and lower economic activity.

In this existing literature, a number of efforts have been done to address this skills gap. For example, the company makes a document about skills that needed and then inform to training providers or its corporate training centre. Furthermore, training providers interpret the skills needed by company from the prism of curriculum arrangement and teaching materials.[5] However, in some cases, it often happens a mismatch between the company needs and workforce availability. A number of studies and company documents have highlighted skills gap and that the performance of workforce is unable to meet the industry needs. The current major gaps or issues in the way the training providers including Higher Educational Institutions develop curriculum are as below:

(a) Mismatch between the curriculum being provided and industry or company requirements. This mismatch happens because the training provider is less updated or less aware about the information and competencies which related with newest skills needed.
(b) There is no or little consultation from training provider to relevant industry stakeholder about training curriculum. In this situation, the information comes from industry might have not been validated or agreed by industry association, and there is no consensus on the competencies required. So that there is no standardized about skills and competence that really needed by industry.

Based on the two major gaps above, the two main questions in this study are: First, how digital technology 4.0 provides solutions about the mismatch between the curriculum being provided and industry or company requirements? Second, how technology can help the communication between parties and validate the updated information about curriculum needed?

Hence, in order to overcome the problems, we propose a Blockchain-based solution for the mitigating skills and competencies gap in workforce. This solution will help all parties to determine and agreed what skills needed by industry. Moreover, training providers will also have consensus with other training providers on the agreed curriculum. Blockchain is an emerging technology that can carry out consensus between parties to agree on, for example, the top 10 skills or competencies that urgently required by a given industrial sector. The stakeholders or participants in this process are industry association, some corporate training centre or training provider who concern on workforce quality and training quality. With the help of this technology, updating information about skills needed and degree of workforce performance will be mutually aligned with each other. In this paper, for proof-of-concept and validation we develop to prototype system using the Ethereum blockchain to meet the needs from industry and education as a competent source of skilled workforce. The rest of the paper is organized as follows: In the second section we discuss the existing relevant literature; in the third section we outline our proposed methodology for Blockchain-driven consensus of competencies and skills for the Industry 4.0 economy; in the fourth section we outline the working of our software prototype and validation; finally, in the fifth section we conclude our paper.

Literature review

Mitigating skills gap in industry

Skills or competencies are an important integral part of sustainable growth in any industry sector because they are associated with increased productivity and innovation.[6] It is necessary to understand what appropriate skills or competencies are needed to face current and future challenges, especially digital era I4.0. The skills and competencies needed in the I4.0 age is quite different compared the skills and competencies of the pre-I4.0 age.[7] To be able to adapt the changes brought on by the industrial revolution 4.0, a worker must have capabilities that cannot be done by machine, for example, the ability to solve problems or creativity. It also involves knowledge about various technological aspects such Robotics, Artificial Intelligence, Internet-of-Things etc. The skills set required for each industry sector will be different and will also vary depending on the role of the person.

Industry sectors are now running in a more and more international and competitive marketplace. Digital applied sciences are breaking down the boundaries between creator, curator and client and impacting on the methods in which organizations engage with their current clients and reach new audiences.[7] The enterprise requires a new, digitally literate group of workers to support and enable the

zone to harness, promote and capitalize on the possibilities this presents. High stage digital skills will be required to allow commercial enterprise innovative sectors to increase their capacity to function throughout a range of platforms and take advantage of new and rising markets and world supply networks.

Alison[4] explained that the issue of skills gap could be faced by any organization irrespective of the sector in which it operates. The out-of-date knowledge and skills of worker will reduce the efficiency of the organization. Hence, company can state the requirements of skills and knowledge of workforce in such work contract. However, with the dynamic changes of environment, skills and knowledge of workers will also need to be updated to enhance business efficiencies and productivity. Alison pointed out that to keep updating skills and knowledge that is suitable for current situation, such tool with the help of Information Technology is needed. In addition, Clark and LeFebvre[8] argued that skills certification system can be built to serve as benchmark for standardized assessment of the critical workplace traits and occupational skills. However, his research did not discuss on how to update skill and knowledge and the attitudes needed for competence certification standard. Forrest[6] and Robinson[9] suggested five tips to bridge skills gap for workforce development which are to establish industrial arts, bring back apprenticeship, continuously develop workforce skills, get involve them in training practice and focus on key end markets. All the suggestion is by means to be more adaptive with the changing of industrial technology based such as the growth of Internet, robotics, and other technological things. Apply for standardized certification, attending training session and listening what industry need. However, these suggestions do not propose an automatic process on agreement about skills and knowledge needed that match between industry and workforce baseline.

Another work on how to mitigate skills gap in workforce has been proposed by Warren.[10] A scheme proposed by Swansea University is trying to change skills gap in engineering project. The scheme is in aim to offer training to companies, allowing them to improve the skills of their workforce about materials and to help people to fulfil their potential by improving their skills and job prospects. The employees attend training to have an understanding about materials for engineering project. This scheme is very beneficial as employees will have update knowledge from the company. However, similar to the shortcoming mentioned about the other methods, there is no tools for providing opinion and make consensus on what knowledge and skills that is currently needed. There is also no recommendation provided on how is training provider will convert that knowledge and skills into certain curriculum. This is a pressing issue and is at the heart of the skills gap facing various industry sectors and across various countries.

Human resource blockchain

There are plenty of research which discuss continuous professional development of staff in the workplace provides a mechanism for addressing skills gaps and storages.[11] However, certain industries are characterized by a high proportion of small and medium enterprises (SMEs) and sole traders. Levels of investment in training and development and business size are closely correlated. SMEs and sole traders have a tendency to underinvest in continuous professional development for themselves (and their employees where appropriate) and face a number of challenges when accessing training, including time and cost. Furthermore, businesses and cultural industries tend not to think strategically about their current and future skills needs.[5] In order to solve this problem, we propose the use of blockchain in Human Resource Management activities, especially to solve skills gap.

The use of blockchain in Human Resource Management function will help the collaboration (and more importantly consensus) between parties in updating skill and knowledge of employees. This function will also providing an update information about what industry needs and what training provider has to do to meets the need of industry. Information that resulted from blockchain process can also be used as source of policy maker or government to regulate competence standard among industry player. Moreover, HR blockchain will execute an automatic process to make consensus between parties involved.

In addition, blockchain could have a major potential on both sides of the employment relationship, from the ability for people to maintain – and control access to – a comprehensive, trustworthy blockchain-based record of their education, skills, and workplace performance.[12] By providing potential employers with access to this 'value passport', individuals would be able to turn their skills, training and experience into genuine value in the employment market. By applying analytics to the data, companies would be able to match individuals to roles much more accurately and effectively. This could be particularly relevant, as skills requirements change in light of the fourth industrial revolution.

Blockchain's ability to enable and support the skills and competencies of the workforce is needed. The benefits of the individual's highly portable and up-to-date 'education passport' will become all the greater – both to themselves and employers – as the trend towards the gig economy continues and younger people change jobs more frequently or opt for portfolio careers.[13] Also, with the younger generation generally being more relaxed than their predecessors about sharing personal information, blockchain provides them with opportunity to do this in a more secure and trustworthy way.

Blockchain will come to pervade business, bringing huge implications to manner in which the educational qualifications of a person are maintained. Blockchain-based

employee lifecycle management approaches would provide the HR sector with trustworthy, reliable and transparent way of carrying out a suite HR activities. Yang et al.[14] outlined the need to have blockchain technology in place for a number of sectors in the digital economy, including the HR sector. Assessing the potential blockchain to enhance efficiency and effectiveness should be considered alongside the broader implications for the future of work.

It is clear from the above discussion of the existing literature that blockchain as a technology could certainly be applied to certain aspects of HR, and that the scope and scale of its implications mean it cannot be ignored. The race to size competitive advantage though blockchain has begun – and HR functions must join it now, or risk being left behind. The second benefit from HR Blockchain in targeting productivity gains. The enhanced ability to match people's skills and performance to jobs would provide an uplift to productivity of the companies. Small and medium-sized enterprises (SMEs) may benefit particularly. The burden of finding and recruiting the right talent is especially difficult for smaller businesses, and anything that can help them do this more effectively and efficiently will boost their productivity. Further high-potential targets for blockchain applications include areas like payroll and VAT, where reducing the administrative burden on SMEs could help them focus more on serving customers and growing their businesses.[15]

Blockchain technology is expected to increase transparency and accountability in value chain networks, thus enabling more flexible value chains.[16–18] In particular, blockchain-based applications have the potential to generate breakthroughs in three areas in supply chains: visibility, optimization, and demand.[17] Blockchain can be used in logistics, identifying counterfeit products, decreasing paper load processing, facilitating origin tracking[19–23] and enabling buyers and sellers to transact directly without manipulation by intermediaries.[24] Moreover, it has been demonstrated that the usage of blockchain-based applications in supply chain networks can safeguard the security,[25,26] lead to more robust contract management mechanisms between third and fourth party logistics (3PL, 4PL) for combating information asymmetry,[27] enhance tracking mechanisms and traceability assurance,[28–32] provide better information management across the entire supply chain, food,[33–37] or better customer service through advanced data analytics (i.e. encrypted customer data) and novel recommender systems,[38] improve inventory and performance management across complex supply chains,[39] and finally, it can improve smart transportation systems and order new decentralized manufacturing architectures.[40]

Some recent research also states the potential utilization of application trends and blockchain features. Utilization of blockchain technology in the field of security shows that the improvement of blockchain application is able to solve the security weakness of the existing Internet of Things problems. The use of blockchain technology can increase productivity, decrease operational IT cost and increase security.[41] Research on blockchain in the field of food traceability, shows the use of the integrated consensus mechanism in the Internet of Thing blockchain technology to help customers and supply chain stakeholders to make their decisions,[38] More comprehensively, the latest research on blockchain technology in an integrated manner from theory to application in the energy sector, recommends that blockchain technology is the best way for energy decentralization to maintain energy sustainability in the future.[39]

Hence, it can be concluded that given the skills gap faced in a number of industry sectors and across a number of countries, blockchain can be used as enabler to solve this problem. It is also concluded that the existing literature has proposed multiple uses of blockchain across a number of sectors for various problem. However, there is no existing Blockchain-driven solution to arrive at a consensus between the industries participants on the skills needed for a given sector. Blockchain is the perfect solution to gather data or as input source of skills (from relevant industry peak bodies all the industry participants etc . . .) which then will use by Corporate Training Centre to make decision making on what competencies are needed. Using the blockchain and gathering the input also means that the Blockchain can be used to arrive at consensus regarding the top 'n' competencies required for that industry sector subsequently and grounded in this consensus, the educational providers can develop micro-credentials or courses with the specific view of imparting.

Proposed framework

In this research, we validate our proposed framework through Focus Group Discussion with several stakeholders. The stakeholders consist of 5 participants from Corporate Training Centre representatives, 2 participants from companies, and 11 industry SMEs representatives. The participants provided valuable input with regard our design framework. HR supply chain for mitigating skills and competencies gap consists of input, process and output which can be visualized in Figure 1.

Figure 1 describes the framework designed in overcoming the skills and competencies gap in the industry. This mechanism can be described in the HR supply chain model which consists of '*input-process-output*'. Information about workforce competence needed by companies is treated as an input. Furthermore, this information will be processed by the corporate training centre and industry community as the parties who responsible for executing training programmes for the workforce. Once the training is conducted, the output is standardized competence workforce that will be used by the industry.

Participants or parties to be involved in the blockchain system are as follows:

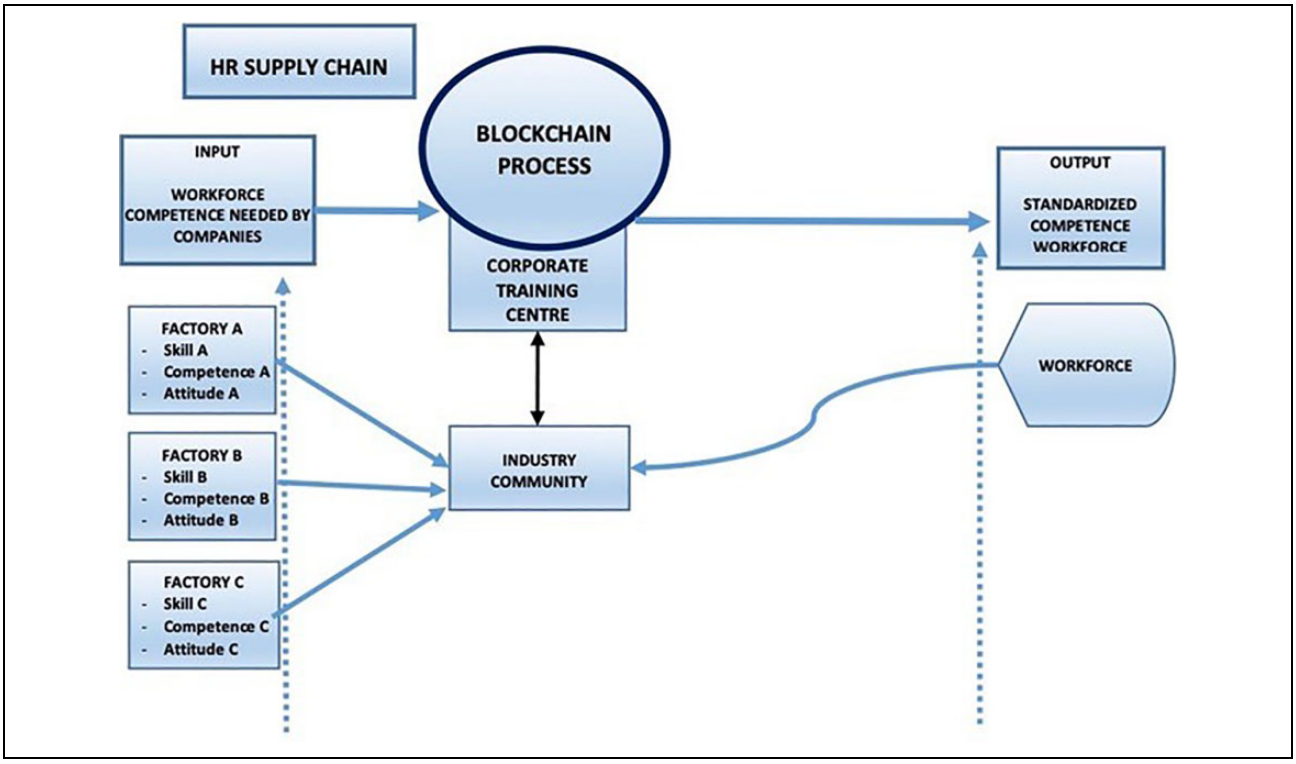

Figure 1. Detail methodology of the framework.

(1) Factories or companies in certain industry
(2) People from the industry community association who will communicate about the competencies needed by the company with the Corporate Training Centre Representatives
(3) The workforce then follows training with a curriculum that has been agreed by the company, the training provider and also the participants.

Those participants will interact in the Blockchain platform. The company will update the Skill Knowledge and Attitudes information and the training body will also update the required curriculum and agree on what needs to be adjusted in the workforce competency training activities.

The detailed working of our methodology is as following

(1) Industry community (peak body of a number of other companies or a member of the industry community) inform the Industry community association regarding the skills gap that the sector is facing.
(2) The Industry community association then announces that it is collecting the desired skills and competencies from the industry. It announces and start date and closing date in the blockchain for soliciting these responses from such industry (represents by Corporate Training Centre).
(3) Various industry participants (corporate training centre representatives) provide their feedback on competencies needed to the Blockchain-enabled platform. At the end of the feedback period, every Blockchain participant is asked to rank all the competencies provided by the community.
(4) Using the underlying Blockchain consensus process, all the competencies that have been provided by the entire industry are ranked by the entire industry community. Consensus is automatically achieved on the ranked skills or competencies by the industry community.
(5) The training providers pick one of the top ranked competencies and develop curriculum with a view to impact skills in that area.

The framework proposed aims to provide a platform to achieve agreement between the various industry representatives for the skills required for that sector. Furthermore, it also aims to provide a platform to connect all the stakeholders in achieving this agreement. The role of the Corporate Training Centre or more appropriately the relevant agency will be a participant in this entire process and will oversee it. From a technological viewpoint, we use to employ a blockchain technology to help all parties informing skills required. With the blockchain technology, information regarding standard of workforce qualification there will be consensus among parties eventually. The Corporate Training Centre can use consensus to set the regulation. The challenge is then on how to collect opinion or argument from input side. As in an industry community will consists of hundred or thousand companies, we need

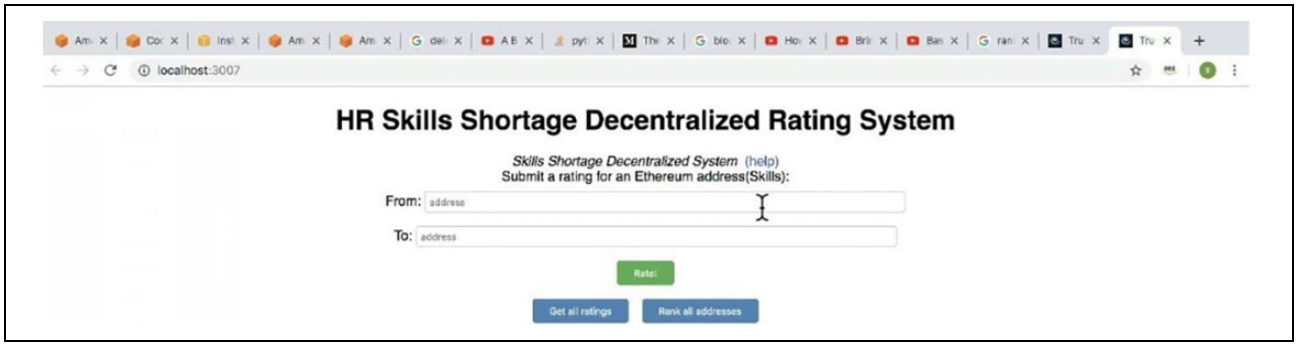

Figure 2. Blockchain based HR skills shortage system.

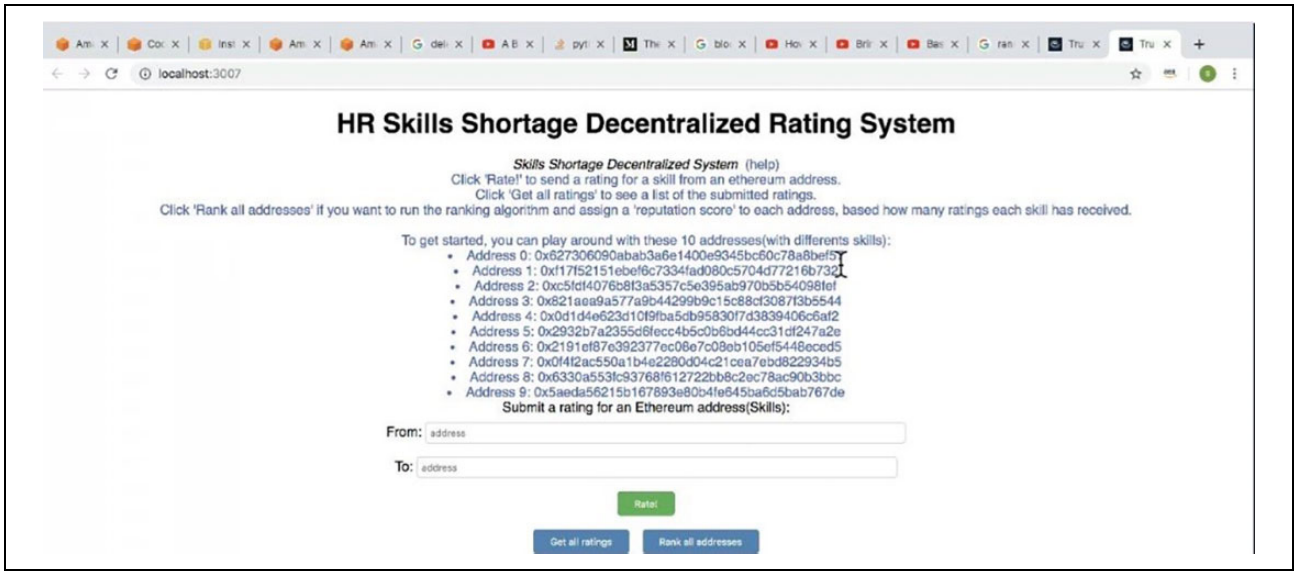

Figure 3. Permitted miners (consortium participant).

technological platform that can gather data safely and automatically conclude with skills information based on industry needs. Hence, by end of gathering input from community, the information will help government board to execute this skill as valid source to be implemented in training provider. In this research, we proposed blockchain technology to create consensus on skills needed by industry. In the next section, we implementation and also demonstrate the proof-of-concept for the framework presented in this paper.

Prototype implementation

We validate our proposed concept on gathering data about competencies and skills needed by the given industry sector by setting up a consortium blockchain's database. A consortium blockchain is one that is open to the members of a given consortium only.[23] For example, for the manufacturing industry in Australia, a consortium Blockchain would be only open to those businesses who manufacture good and are physically based in Australia. In this case, Blockchain offers a host of benefits inherently by design which include: transparency of the provided information, trustworthiness of the voting process, democratic process of soliciting the skills and the votes and finally auditability in the sense that member of the consortium blockchain can audit the transactions. In this research we use Ethereum for the development of the blockchain platform blockchain development with node.js. The landing page of the blockchain prototype is describe in Figure 2 as follows:

Each participant in the blockchain has been provided with a pseudonym. The 'From' field refers to pseudonymous identity of person providing feedback on the needed skills. 'To' refers to the blockchain address where the provided feedback will be stored. Anyone can join or participate in this blockchain, in which their eligibility as a participant have been validated before. The blockchain has an immutable-hack proof since the network of a blockchain exists at a place of consensus and is self-auditing. Changing even the smallest part of this blockchain would take an enormous amount of computer power to take over an entire network. Once the participants are registered or listed in the

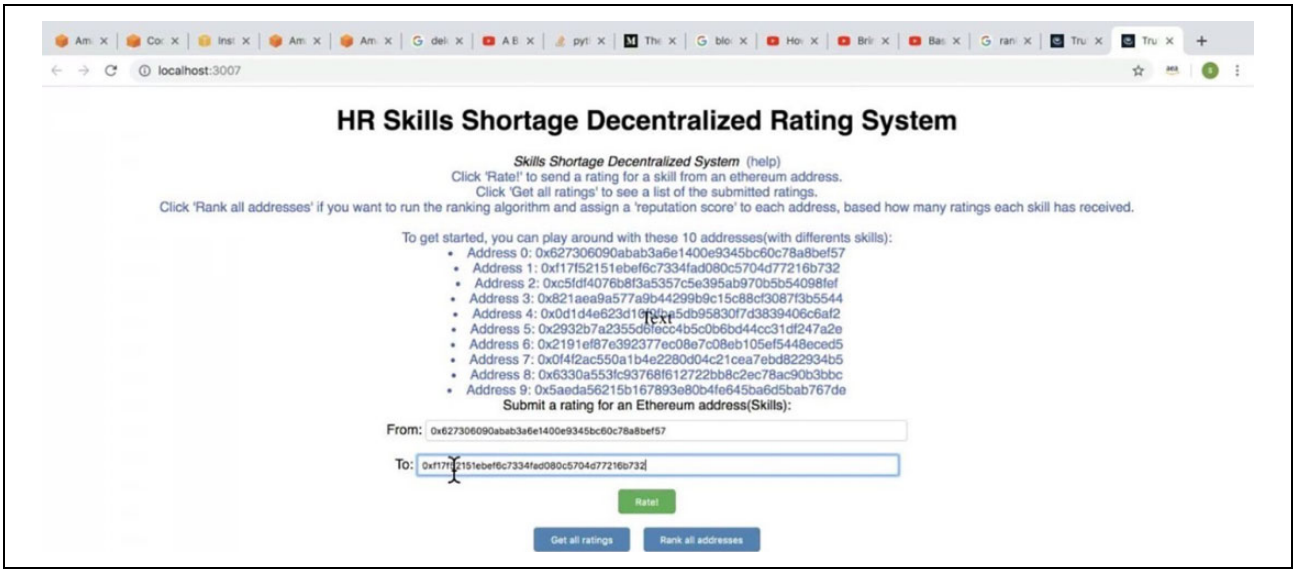

Figure 4. Skills information getting scored on the HR skills shortage blockchain.

blockchain, their credentials will be stored in the blockchain. For the purposes of this prototype we used 10 consortium members. The pseudonymous identities of the 10 members is show in Figure 3 below. Any member belonging to the consortium is eligible to join the blockchain and provide feedback on the required skills. However, on the blockchain the participants transact using pseudonymous identities.

Figure 3 showed that there are 10 participants who joined in the blockchain. As we can see, each participant will be awarded a pseudonymous identity. This code is as participant's blockchain identity. Blockchain gather this data and then store it. When a participants provides feedback on the skills needed (and subsequently on the voting process) the pseudonymous identity is used.

Once a participant has a pseudonymous identity she/he can start to write their idea or arguments on what skills that currently needed for his company. This is illustrated below in Figure 4.

In Figure 4, we can see that each Blockchain participant can provide feedback on the skills required in that sector. For example, the participant represented by address 0, provides feedback on what skills s/he wishes to see in the future workforce. Address 0, address 1–address$_n$ are the identity of feedback provided by participant. The Blockchain then will create block representing the skill provided (or multiple blocks regarding each skills) and adds them to the Blockchain. In real case, a participant or a company with ID address 0 will write in the blockchain regarding workforce skills needed. All participants can write and make opinion for any skills required. The new Blocks would need to go through a consensus process and subsequently it will be stored in the Blockchain. This is illustrated in Figure 5.

Figure 5 showed that several participants have given their opinion about skills required. Blockchain then compiled suggestions by the participants and stored them in the form of blocks. The black ink shows the result of feedback from each participant about the skills required. In real world, the number of participant can be unlimited. In this case, for the proof of concept purpose, we used five participants to illustrate the working of the Blockchain-based solution for this problem. These participants are industries player which could be director, manager, or important person in a company. We can see that as discussed, automation is one of the most popular emerging technologies currently being deployed in business that make it possible to enhance the human experience for both the organization and the government. After all information about skills and knowledge is present in the blockchain the participants will be asked to rank all the skills provided by the entire consortium in a numerical and sequential manner. Each eligible consortium participant can cast vote and they are recorded on the blockchain. At the end of the voting process, the blockchain will automatically rank the top listed skills needed from the industry. This is illustrated in Figure 6.

From the Figure 6 above, we can observe that the black font listed, there are five ranking with percentage information. For example, first rank is for most skills suggested by the industry. 41.3 percent participants vote for this skill, second rank is another skill proposed. By the end, blockchain will give us result of skills required by industry community. This result is valid as it is communicated among the network and based on the consensus. It is important to note that using our blockchain-driven approach every participant gets to provide feedback on the skills in a democratic manner. Furthermore, every participant also gets to vote on the skills in a democratic manner as well. The result is that the output of all the needed skills and their ranking represents the industry-wide consensus.

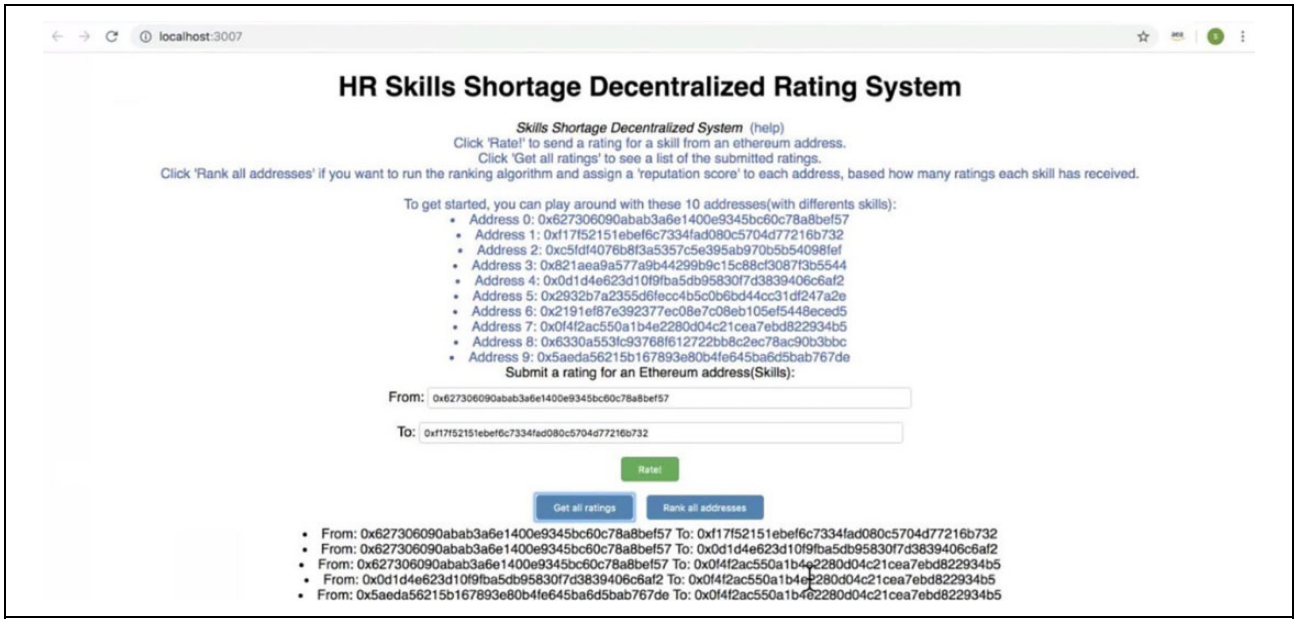

Figure 5. Permitted miners (in blue) and the skills required (in black).

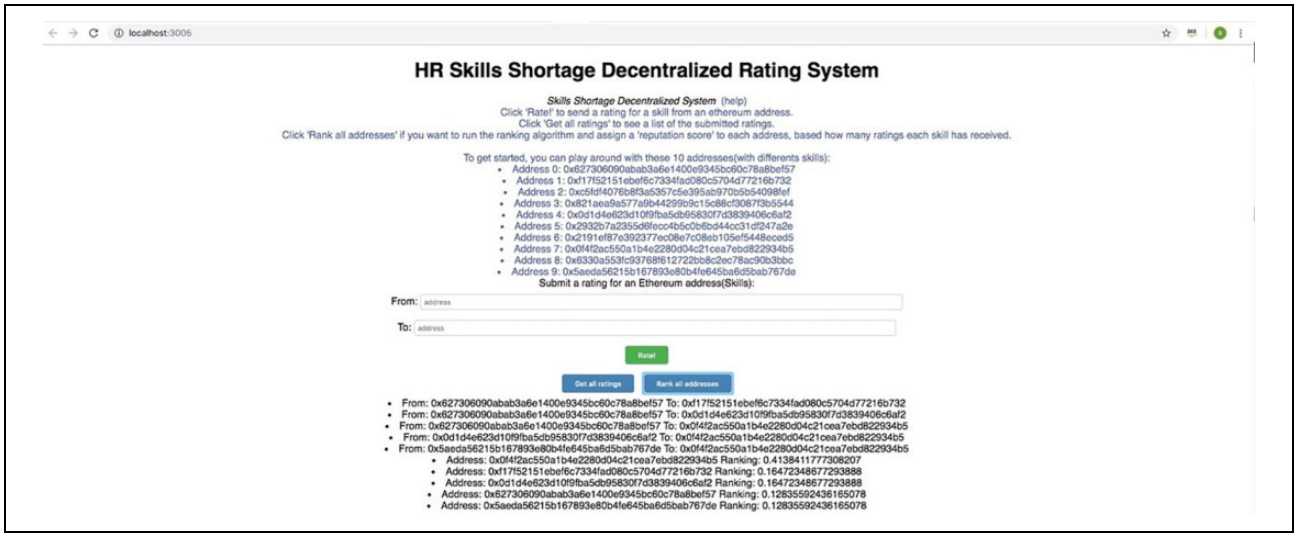

Figure 6. Ranked skills (in black).

Managerial and academic implication

Designing a curriculum or training content to improve workforce skills, knowledge and attitude that fit with the company's needs is one way to reduce the gaps that exist between the competencies held by employees and the competencies needed by the company. The very dynamic external environment and market demand make the urgent need to design content or curriculum also have to be agile and dynamic. Blockchain helps corporate training centres to get updated, accurate and high consensus information with regard workforce competencies from stakeholders. When deploying competencies needs in Blockchain, the security and comprehensiveness of traceability information can be strengthened. Further, all related HR training activities and milestones are managed in the blockchain for effective information retrieval.

The proposed blockchain–IoT application for training material needs includes the lightweight and vaporized characteristics, to enhance system adaptability and scalability. In addition, the training quality evaluation, including content, trainer and satisfaction feedback is modelled automatically. Therefore, training content quality monitoring can be more reliable where the actual effects from workforce activities in the workplace can be reflected. The typical blockchain is not practical in real workplace or industries

when used for content training traceability, as it is impossible to manage a group of miners to conduct block mining activities, which are both time-consuming and waste computational resources. Therefore, HR training blockchain is proposed in this study to address the above concerns in implementing blockchain in HR training management. Without a group of miners and mining machines in supply chain stakeholders, the lightweight and vaporized features in blockchain are essential to boost the block updated information, forging process and to release latest competence information needed by the workforce.

From the perspective of organizations, effective data and information management is crucial, which can be used to understand the competencies of workforce to deliver high work performance. IoT technologies are applied to collect and analyse data related to workforce competence needed by companies in such industry, while blockchain technology provides the structured information management for content of HR training. By integrating the above two technologies, the blockchain–IoT application is formulated to address the practical needs in skills gap mitigation.

Compared with the traditional cloud-based training needs systems, the consensus mechanism and distributed network to the traceability information are improved, such that updated skill content can be completed in an efficient and effective manner. The supply chain stakeholders can share traceability information in the peer-to-peer network, where the data of workforce competencies conditions are used to establish dynamic training quality management. Thus, the workforce competencies that are standardized by the industry is created. Furthermore, in the HR management practices, the high dynamic changing of the external environment makes the company must adjust the competencies that will be provided to its workforce. Therefore, failure to provide good trainings to improve competence in accordance with market needs may affect the product or service quality delivered, or even damage the sustainability of the company.

To create a better atmosphere in workforce performance, the proposed system enables not only holistic HR training content, but also dynamic workforce competencies according to the company needs. Mutual trust and employee loyalty can be improved through deployment of the proposed model, while the training quality can be maintained to facilitate high workforce performance development.

Conclusion

HR training supply chain is the link in the process of input up to output. In this research, input means skill that needed by industry, process means approval from Corporate Training Centre or training provider board, output means competence workforce that meet the industry requirements. Meanwhile, in order to get information about skills required by industry, we use technology application. Technology, especially AI (Artificial Intelligent) and blockchain, are certainly transforming the human resource task. Although it appears expensive, the benefits, which include saving time, far outweigh the cost. Even though it is hard to find the most skills needed from the industry, the Corporate Training Centre board as representative of company will gather data and use the data for decision making. Over time, both blockchain and AI will disrupt human resource management practices in its entirety. Industry and Corporate Training Centre will be able to leverage these tools to make the skills matched with their needs. Furthermore, training provider will be able to develop the curriculum in accordance with the industry needs. The validation result with prototyping blockchain shows that blockchain is able to generate information about skills required by industry. This information will be used by the Corporate Training Centre to arrange procedure about workforce competence standard. As the result, this information will be used by the training provider to arrange curriculum.

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