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## An Analysis of Quality 4.0 Competency Level in the Malaysian Electronics Industry

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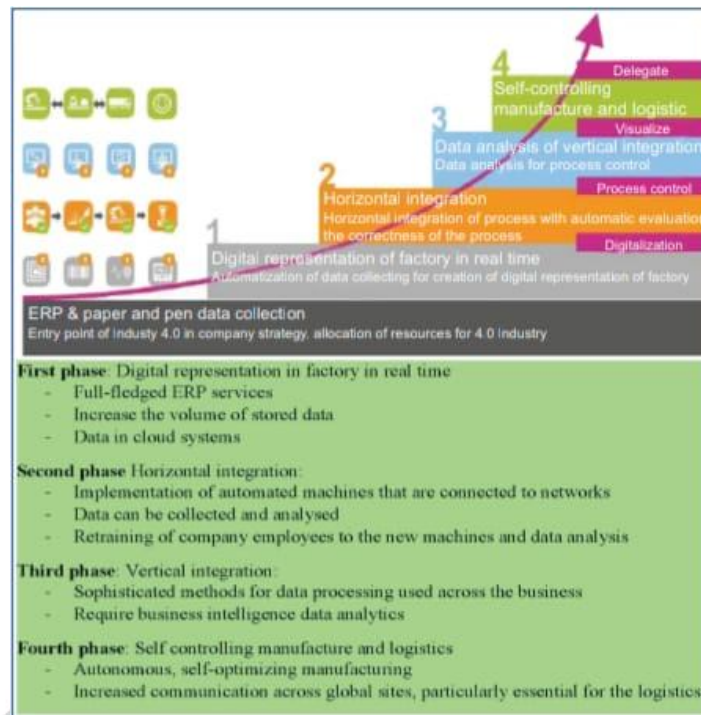
### Abstract:

*The main motive of this research is to explore the competencies level of quality assurance officers in the Malaysian electronic industry needed in the quality 4.0. In order to adopt the relevance of this study, the case study has been carried out in the southern Malaysia in the electronic industry. In doing so the main objective of the study are what are the changes in the technological shift anticipated to affect the future roles in the quality of industry 4.0? What are the competency breach in between the future and current responsibilities of quality assurance officers? What are the practices and perspectives connected to quality roles? How can these identified gaps be closed to reach the quality difficulties of industry 4.0? Moreover, the research methods used in this research is based on comprehensive literature review on the technological shift in the industry 4.0 as well as the effects on quality role together with competencies which might be needed in the future. Document review was also used in this study to examine the current roles of quality assurance officers in the electronic industry. The empirical information was collected based on surveys carried out on the 64 quality assurance officers with a 98% response. Interviews were also conducted. The results of research found out that quality assurance officers needed media and technical skills in order to interpret huge volumes of information from the procedure in order to make tactical decisions.*

**Keywords:** *Competencies, technological shift, practice and perspectives, media and technical skills, tactical decisions.*

### Introduction:

Industry 4.0 explains the fourth industrial revolution that was mentioned earliest in the year 2011. The main purpose of this was to implement the Germany economy on the basis of high technological strategies as well as to transform various industries through merging the internet and digital technologies to the conventional industries. Stancioiu (2017) found out that around 33% of the worldwide industrial part already have higher levels of digitalization, but the level is anticipated to rise up to 72 percent in the next five coming years. Nevertheless, Lu (2017) found out the interest of the industry 4.0 such as offering more pliability, reducing the cost and lead times as well as modifying with the small batch sizes. Additionally, Benesova&Tupa (2017) explains the execution of quality 4.0 in four essential steps as shown below.



### Relevance of this research:

The main purpose of this research is to investigate the competency level of quality assurance officers, their current skills as well as the new skills which are needed in order to adapt industry 4.0, through using electronic industry in Malaysia as the case study. Besides, the study will be timely and relevance to make sure that the quality assurance officers can change industry 4.0 via working and acknowledging to close the available breach in the knowledge and quality skills which are needed. Different studies about the roles and responsibilities of quality directors have revealed different views on the work of quality comprising analysts, educators, consultants and trainers, in supporting and leading improvement tasks, enhancing product quality as well as considering consumer voices in company (Williamson, 2020). Further, the department of quality is typically responsible for the overall products quality as well as processes such as the quality of raw materials, process, product and the outgoing quality and making sure the quality management system is maintained according to the given procedures. Also, the consumer quality problems are guided by the quality squad, who work in conjunction with the functional squad in order to settle this by use of quality items (Goetsch & Davis, 2016). Thus, the present skills needed by the quality directors might involve, team work, assessment, analysis and assessment, leadership, communication, decision making, managing people, problem solving and role modelling.

In addition, the digital age started with the mobile technologies and internet that saw a business transformation into online businesses, which contained e invoice, e signature and e payment. As an outcome of this technological exchanges with the new advancement in artificial intelligence and robotics, many positions of jobs are at a high threat of having restored by technology. Besides, Lyle (2017) proposed that producers must accepted technology such as

automated collection of data as well as the industrial internet of items in order to make the process of quality assurance more effective. Moreover, the impacts of these rapid changes in technology have already been felt by the job market in Malaysia as stated by Singh (2018). Singh found out that according to the Malaysian Employers Federation (MEF) executive directors who said that one of the elements that is causing job losses is the growth of information technology and robotics. Nevertheless, Kasriel (2017), foretold out that job opportunities might not lack yet there will be a shortage of professional skills that will not fill the future jobs. Cimini et al (2017) pointed out the literature gap in the needed skills and roles of the employees for the industry 4.0 and hence this study aims at using the case study in order to examine the gaps in quality officers as well as make recommendation in order to ensure that the quality assurance officers are ready for the industry 4.0. Additionally, this is an exploratory research and it will be accompanied by other literatures using larger samples and mixed research methods.

### **Electronic manufacturers:**

The electronic industry which is the main context in this case study refers to an ISO 9001 certified international electronics producers in Malaysia (Oliff & Liu, 2017). The industry comprises of 30 companies internationally which hires more than 12000 employees in the world. Additionally, there is the central team of quality management system which is known to handle the overall organization and the procedures for the Malaysian industries. Besides, every site is known to handle various consumers and thus, each operations in the industry might be customized further to meet personal site consumer requirements. The quality management team in every site is responsible for the incoming quality of raw materials, in procedure quality to the intended quality as well as consumer quality. Waldrop (2018) found out that the routine center of the quality managers and quality department involves the procedure as well of functions, offering expertise on the new technique and the managers transferred to the quality inner documents by the engineers and used the manufacturing association put up the products. Nevertheless, with the emergence of industry 4.0 the electronic producers began to move towards the process of automation. In doing so the main objective of the study are what are the changes in the technological progresses anticipated to affect the future roles in the quality of industry 4.0? What are the competency breach in between the future and present roles of quality assurance officers? What are the practices and perspectives connected to quality roles? How can these identified breaches be closed so as to encounter the quality difficulties of industry 4.0?

### **Literature review:**

In reference to Lu (2017), various researchers and scholars have defined quality 4.0 from wider views thus, there is no definition adopted in a complete accord. Benesova & Tupa (2017) stated that the primary creativity of quality 4.0 is the looks of the highly technological industries which are

related to the CPS manufacturing space that permits machine-machine, machine human interaction or even communication between human- human through internet of things, people and services via the huge volumes of generated information. This means that it will need highly educated and qualified employees in order to manage these technologies. Moreover, this plan is known to manifest beyond one organization to other firms, with integrated data into supply chain and cloud processes which are put into order in the effective space (Szozda, 2017). Jacobs (2018) examined four main feature of manufacturing which had agreement from various scholars as the future creativity in the quality 4.0. These four aspects are the factory that has the intelligent processes in the decentralized systems yet monitored and controlled interdependently, enterprise with the real time connections of communication in the supply chain from the logistics, resources, consumers and suppliers. The third aspect is products that is the carry and smart information which can be analyzed, transmit the feedback as well as have the abilities to get tracked. Finally, the last aspect is consumers who have the capability to put up orders on time of adjusting their structures without communication and charge with the advanced items. Hence, these features will be typically use as the framework in order to explore the changing progress which are assigned to the industry 4.0.

#### **The changing progress in the industry:**

Quality 4.0 seems to be fully using employee's talents and skills instead of advancing towards the workless productions. It might be the essential success element to adapt the new technologies. Nevertheless, HMI resolution can enable the increased operator in the exercise to interconnect with the intangible digital contents as well as assets when acting towards the data in the physical world by use of sensors, in order to attain live information from various stages, hence permitting person operating to have the wider process of knowledge, including the performance of checking the quality (Longo et al., 2017). Quality assurance officers also are people who can make informed decision, improve quality and estimate the cost of labor (Gakill, 2017). Thus, the quality roles might shift from manual work towards automatic processes which needs technical experts (Dal Porto, 2018). Also, quality assurance officers might require to understand various analytics and predictive items. Further, Roblek et al. (2016) proposed digital thinking in order to control these processes in different ways. Employee education as well as training programmes of the officers in the future will be using the effective resources, for instance Google glasses that will help the inspectors learn through showing instructions and diagrams as well as enable quality inspection that will be carried out 20 percent quick. The management quality assurance officers might be perceived as the main, tactical role as the agent change as well as the excellent expert process, in the upcoming as companies find out into the creating value for stakeholders and consumers via utilization of transformation (Keim & La Londe, 2017).

Nevertheless, the difficulty of the huge information in the trending industries might result

into quality assurance officers needing to team up with the different skills sets, such as IT practitioners, process subject and statisticians for instance, the resource directors responsible for the content of artificial intelligence so as to analyze and understand data and the resource utilization. For instance, to analyze the main causes of machine issues and performing the production quality checks to lower these steps. Additionally, this will enable the quality assurance officers to establish whether devices are learning what it was expected to be learned. The electronic smart factories with machines which are cyber physical systems as well as those that constitute of robots which can organize themselves, connect with humans and self-optimize through AR tools as well as other smart items in order to give rise into smart goods, which have processing and controlling abilities in a much localized production.

### **Research methodology:**

The approach used in this study is a mixed way for collecting quantitative information by use of the method of questionnaire survey, qualitative information by use of semi structured interviews, online data, the approach of content analysis, literature texts as well as the inner document study. Additionally, there are various classification of mixed approaches of research design. Thus, in this review, there is a relation of the parallel design where quantitative and qualitative information was conducted at the same time.

The research also used the study of documents in order to determine the changing trends in technology as well as its effects on the future responsibilities of quality as well as to examine the competence breach. Competence needed by the quality assurance officers in the industry 4.0 was carried out using secondary sources of text information from different quality journals and technology together with the authoritative articles. There was use of purposive sampling method that is a common method used in content analysis. The competence of the present quality assurance officers was examined at the electronic industries by studying up the procedures of inner quality management from the company database.

Additionally, the practices and views connected to the quality roles was identified by the structured interviews and survey questionnaires. The questionnaire questions were on the basis of the theoretical view which were acquired up from the literature breach identified. Besides, the Likert-scale questions was typically used in the questionnaire in order to permit the people to show how strongly they disagree or agree (Liao et al., 2017). The scale was coded from a scale of 1-5 where the respondents were to tick appropriately. Moreover, the questionnaire survey was structured in a way to find out the present competencies as well as the future quality competencies for the quality assurance officers. The questionnaires were issued to quality managers, engineers and quality executives across nine firms. Nevertheless, the research was carried out on 64 quality assurance officers as it was a manageable and reasonable position to the survey population. Further, with 95%

of confidence level as well as 5% error margin the sample size was minimized to 44 participants with a targeted retaliation rate of 88% for the 50 samples. Also, the questionnaires was issued to the quality leader within the stipulated dates in order to make sure that the responses were reliable. The interview queries were based on the theoretical perspective which were extracted from the identified gap. In order to meet the main objectives of this research the interview participants were identified by use of purposive sampling whereby the judgment was used to point out the best answered cases of the research queries.

### **Research Findings:**

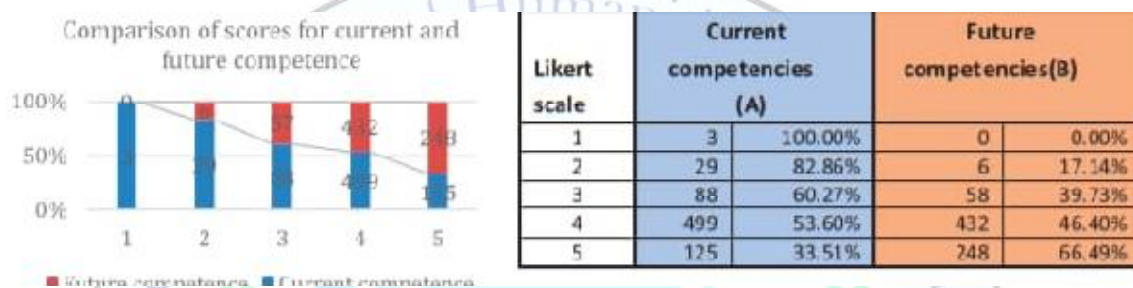
The documentary investigations from the literature in order to examine the gap between the future and current quality professional was examined. Nevertheless, twelve proposition was derived from these results as well as those that was used in the interviews and questionnaires. Besides, the questionnaire response rates were as higher as 96% in comparison with the research findings as the sample was from a 100 percent sample population of quality assurance officers in the electronic industry (Zavadska & Zavadsky, 2018). Hence, the high rate of response offers high confidence which the data has represented the community well. The analysis of questionnaire offered the quality assurance officers perspectives on the competency breach as well as the whole outcome indicates an rising trend on the response of questionnaire towards the future competencies in comparison with the 33% of the current competencies. Therefore, the findings of every propositions from questionnaires were however triangulated with the findings form the interviews and document reviews as shown below;

*Quality assurance officers needs increased knowledge on their jobs because of the rise roles from the physical to the automated processes in production of electronics.*

There was no remarkable changes on the understanding processes needed between the future and current artificial intelligence according to the view of respondents. Besides, the questionnaire analysis outcomes revealed that there is need of high present knowledge. Moreover, both operations and finance directors head revealed that there must be a rise in the requirement of knowledge in the coming years. Also, on the basis of answered questionnaire, the quality assurance officers strongly agreed that there was an urge to know the procedures even at the current state. This is due the present processes are needed to enhance the service and product's quality (Goetsch & Davis, 2016). Further, the second element indicates that the new knowledge or the art need in the future. With regard to this, the results of questionnaires indicates that there is no difference in the future requirements because of the potential lack of vulnerability of quality officers in the industry 4.0, yet the big management had a varied perspective (Domingues et al., 2020). The director of finance stated that rise of understanding need on industry 4.0 and to attain the knowledge on the financial elements connected to loss and profit as well as business awareness. Also, the heads of operations

also expressed their feelings that there was a requirement of increasing understanding by the horizontal and vertical integration in order to gain enough understanding so as to protect the intellectual property of the industry better. The head of talent development suggested that willingness and personal skills to adapt the changes and IT were needed for industry 4.0.

The document investigation has further accepted with the finding thus proving there is a big gap in the present quality assurance officers in the state of art understanding. For instance the new knowledge will be digital thinking for process management. The automated processes might change roles of employees in order to coordinators as well as problem solvers and thus, there was a requirement to be technically skilled on decision making. Hence these outcomes confirms that an increased knowledge on job must be needed in order to understand the quality 4.0 process for the quality assurance officers so as to make excellent quality decisions.



*The quality assurance officer’s role of transforming from functional to the strategic roles as one of the change agent in order to identify creation of value chances for the stakeholders.*

Based on the outcomes found from document review and questionnaires, there was a significant competency gap which is the future responsibility of quality will become more tactical. Additionally, the director of operations seemed to be more skeptical depending on the extent the organization is prepared to develop these competencies and the organizational structure as the flatter structures might allow the quality professionals to have an access of data to make strategic decisions. This might be attainable in the quality 4.0 factories models as the decentralized system was stated by Qin et al. (2016). Besides, the head of talent development added that other factors included capabilities and plan to utilize the unstructured and structured data in order to enable internal auditors to have the higher understanding levels of the business operations and processes so as to offer strategic advices.

*Quality assurance officers will need higher media and technical skills to the use of new technologies, for instance, big data needs data mining software, augmented reality tools like smart glasses.*

According to the Mann-Whitney test outcomes of the p value less than 0.5, the main difference between the median of B15 and A3 which is not equaled to 0. Statistically, this concludes that there is a difference in these two medians. This showed that there was a shift towards the

stronger agreements of the respondents which quality assurance officers will require higher media and technical skills to meet the use of these new technologies for the future technologies. Also both documentary and questionnaire analysis outcome agreed that there will be the need of high technological and media skills for the future quality assurance officers. Besides, this was the same expectation from the study conducted by Dal Porto (2017) about the quality assurance officers, where they expected that the new augmented media items like smart watches and smart gloves might be used for the quality management. However, after agreeing on the requirement of having higher knowledge of these officers, the finance directors gave their suggestions on the current Malaysian education systems since they cannot offer the skills and knowledge which are needed to feed out the counter parts of Singapore who are ahead of the industry 4.0. Siti Nur et al. (2018) places all responsibilities on the employers in order to offer upgrading skills on the new technology. The head of talent development also agreed that the higher order thinking and the skills development must be needed because of the increase in complexity of the shop floor which offers new challenges to the workforce with the different user face technologies. Further, Sung (2018) pointed out that there is a need of different systems of education that needs to be introduced so as to meet the needs of these sets of skills, even though employees might not benefit from this approach as well as take more time in order to resolve.

*There is a need of quality assurance officers to be aware of data security because of the use of information on servers and IOT technology.*

According to the test results conducted, there was a shift on the stronger agreement by the respondents on that the future competencies needs awareness of data security on the quality assurance officers. Both document analysis and questionnaire concludes that there is a competency gap on the knowledge of data security on the quality assurance officers. Also, the head of finance operations and directors agreed that quality must play an essential role in the security audits of data that might assist in providing external security risks and entity assessed by the auditors. In addition, the information security is a vital aspect of quality 4.0 since the online integration of various entities makes many cyber threats a common problem that might result into the substantial effect and loss to reputations of the producers, thus justifying data security inclusion in the audit programmes.

Other findings are that the quality assurance officers requires to determine the huge volumes of information in order to examine the main source of issues so as to enhance these complex processes. In this the respondents strongly agreed that there is a need to examine huge volumes of data in the future so as to examine the source of issues to enhance the challenging processes in the industry. Even though the quality assurance officers agreed that their future needs examining huge volumes of data in order to improve these processes based on the documentary and questionnaire results did not find this gap. This might be as a result of current professionals already needs to have these skills of



problem solving as well as analytical understanding for the statistical decision making. Moreover, in the industry 4.0 the data from processes and products will be complex and vast, thus needing workers to have the ability to examine the best data that could be beneficial in order to solve particular issues as well as using the predictive analysis.

*Quality assurance officers needs the access to the reliable sources for the continuous learning in the changing environment*

In order to adapt in industry 4.0 environment, the respondents showed that the future quality assurance officers must require access to the reliable sources for the continuous education. Also, this finding was supported by document analysis which showed there was a requirement of access of reliable sources in coming years. In the industry 4.0, there is a self-direction learning, with the abilities of correcting and controlling work unaided and autonomously use of the learning content by the workers, can enable the work learning based. Besides, this was agreed by Benesova&Tupa (2017) which the system of education must be industry 4.0 in order to combine effective and real world information so as to adapt industry 4.0. Moreover, it is anticipated that this method of learning will drastically change in the coming years because of the higher level of skills needed as well as the availability of reliable learning sources.

*Quality professionals also need to be flexible in the time and workplace because of the increased virtual working environment*

According to the Mann-Whitney results, the respondents stated that there was a strong need for the quality officers to be flexible on their time and workplace in the future because of their effective working environment. This was supported by the documentary analysis and questionnaire that indicated the future quality assurance officers must be flexible on their time. Also, the director of finances agreed that the virtual communication tools as well as the future newer effective tools must enable flexible working arrangements. In reference to the heads of operations, there is a possibility of the automated systems which allows workers to access data without being involved with the manufacturing areas. Additionally, the head of talents development concluded that this could allow the workers to work virtually in the future by use of their mobile systems. On the contrary, this would be a negative impact since it would affect the life balance of employees. Thus there was a need of setting boundaries that would make sure that their work dose not intrude with the private lives of these workers. Also, it was a concern that some of the employees might not adapt to the new technology swiftly.

### **Discussion:**

On the basis of literature research, all the findings were accepted based on the competency need of the quality assurance officers in the industry 4.0. According to (Wagner et al., 2017) the research has found out that quality assurance officers needs rise job knowledge because of the

connections with the machines as well as to interpret the processes of live data. Also, quality assurance officers need higher media and technical skills so as to make the use of AR items in order to enhance the machine process and performance. Besides, with the transparent and vast data from the related systems as well as use of the cognitive technologies, quality assurance officers need to have their access to important information in order to find the risks as well as provide the strategic advice to the industry. Moreover, the rise of sharing huge volumes of data across the chains of value might result into rise of threat of data security breaches that these officers will require to be aware of.

Further, the quality assurance officers will need to be highly skilled at examining the main sources of issues from the huge volumes of data, in order to solve these challenging issues. For instance, making sure difficult deep learning of algorithm for the machine education is meeting the expected functions. In order to have excellent competencies, quality assurance officers need access to reliable sources of information, for instance, through working with small-medium sized enterprises as well as technical experts. Quality assurance officers might also require to learn the usage of new tools for instance, the use of data mining software which is the primary driver of industry 4.0. Additionally, the effective relations across the multi sites as well as the chain of value, quality assurance officers will have an increased connection across different virtual platforms in their real time in the industry 4.0, as well as there will be the requirement of having effective abilities of communication. For instance, dealing with the effective consumers which are no longer defined well as well as maybe form the diverse cultures. An increase in decentralization, quality assurance officers need to be leaders so as to make decision with the assistance of artificial intelligence technology. Because of complexity, as well as young individuals are entering in the industry, retention of efficient knowledge is needed and the requirements to be open so as to enable sharing of high quality practices in the company. With the rise of virtual work as well as the use of mobile applications on tablets and phones, information from these processes might be available quickly to the quality assurance officers, which results to the ability of making decisions at any place or time in the fluid environment, flexible and virtual. Finally, these professionals need to be motivated continuously so as to keep up with the changes in the working environment.

### **Conclusion:**

The main aim of the study was to find out the competence breach between the present quality assurance officers in the electronic industry with the proficiency needed in the industry 4.0. Besides, this caused to the third main aim of this paper of identifying the perspectives of stakeholders on the basis of results found from the space found, to triangulate the results, in order to summarize the competency gaps of the present quality assurance officers in the electronic industry. Further, the study was to come up with recommendations on how to produce the quality assurance officer in the electronics manufacturers for their main role in the industry 4.0. It is recommended that workers in

the electronic industry is anticipated to begin at the second steps with the intelligent automation is starting being executed. This recommendations solutions is to overcome the competence gap. Creating recognition through exposure of the new technologies by attending outside training, exhibitions and industry demonstration of the latest software and tools by the suppliers. Training on data security and IT risks is also needed and the access of the business information for the quality audits that might be offered by the information technology section. Moreover, the study has examined the methodological, technical, personal and social competencies gap of the quality assurance officers in the electronic industry through looking at the changes anticipated in the industry 4.0 as well as the key competencies which the quality professional in the electronic industry will need to adapt their primary roles in the industry. In addition based on the interview and questionnaire comments of the key personnel, it is concluded that the quality assurance officers lack enough knowledge of their new responsibilities in the quality 4.0 as it was suggested by the head of finance. However, the full execution of quality 4.0 will need fundamental investment in order to maintain and establish an IoT infrastructure as well as the electronic industry appears to be the adapting phases beginning with e learning (Duarte, 2017). The primary benefit of quality 4.0 technology was indicated by the Philip's new Dutch factory with the robotic technology which was able to produce similar output with a one tenth of the workers in the china factory. Nevertheless, the industry shared the same perspectives which the industry 4.0 is expected in order to reduce the production cost. Boulanger et al. (2017) proposes that the opportunity window for companies to leverage new technological skills from the year 2018- 2022, so as to enable workers to attain full potential in the highly valued added events. Further, the electronic industry might require to maintain to this timeline so as to keep a competitive advantage.

### References:

1. Benesova, A. and Tupa, J. (2017), "Requirements for education and qualification of people in industry 4.0", *Procedia Manufacturing*, Vol. 11, pp. 2195-2202, doi: 10.1016/j.promfg.2017.07.366.
2. Boulanger, M., Chang, W., Johnson, M. and Kubiak, T.M. (2017), "The deal with big data", *ASQ Quality Progress*, Vol. 50 No. 9, pp. 26-33.
3. Dal Porto, L. (2017), "Rise of the drones", October, *ASQ Quality Progress*, Vol. 50 No. 10, pp. 8-10.
4. Dal Porto, L. (2018a), "The state of manufacturing", January, *ASQ Quality Progress*, Vol. 51 No. 1, pp. 10-12
5. Domingues, P., Sampaio, P., Correia, F.D.V. and Uzdurum, I. (2020), "Scanning for a superior skill set", *ASQ Quality Progress*, Vol. 53 No. 9, pp. 16-27.

6. Duarte, J. (2017), "Data disruption", September, ASQ Quality Progress, Vol. 50 No. 9, pp. 20-24.
7. Gaskill, T. (2017), "Facing new reality", February, ASQ Quality Progress, Vol. 50 No. 2, pp. 10-12.
8. Goetsch, D. and Davis, S. (2016), *Quality Management for Organizational Excellence: Introduction to Total Quality*, 8th ed., Pearson, Boston.
9. Jacobs, D. (2018), "Quality 4.0 impact and strategy handbook", available at: <http://www.insresearch.com/research-library/research-articles/-ebook-quality-4.0-impact-and-strategy-handbook>.
10. Kasriel, S. (2017), "4 predictions for the future of work", World Economic Forum Website, available at: <https://www.weforum.org/agenda/2017/12/predictions-for-freelance-work-education/>.
11. Keim, L. and La Londe, P. (2017), "Changing competencies for quality professionals report", pp. 1-23, available at: <https://asq.org/quality-resources/research>.
12. Liao, Y., Deschamps, F., Loures, E.d F.R. and Ramos, L.F.P. (2017), "Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal", *International Journal of Production Research*, Vol. 55 No. 12, pp. 3609-3629, doi: 10.1080/00207543.2017.1308576.
13. Lindborg, H.J. (2017), "Preparing for the revolution", August, ASQ Quality Progress, Vol. 50 No. 8, pp. 10-12.
14. Longo, F., Nicoletti, L. and Padovano, A. (2017), "Smart operators in industry 4.0: a human-centered approach to enhance operators' capabilities and competencies within the new smart factory context", *Computers and Industrial Engineering*, Vol. 113, pp. 144-159, doi: 10.1016/j.cie.2017.09.016.
15. Lu, Y. (2017), "Industry 4.0: a survey on technologies, applications and open research issues", *Journal Of Industrial Information Integration*, Vol. 6, pp. 1-10, doi: 10.1016/j.jii.2017.04.005.
16. Lyle, M. (2017), "From paper and pencil to industry 4.0: revealing the value of data through quality intelligence", *Quality*, Vol. 10, pp. 25-29, available at: <http://eds.b.ebscohost.com/eds/detail/detail?vid52&sid586dc4e28-91c1-42c1-a0bd-10472d7a894a%40sessionmgr104&bdata5JnNpdGU9ZWRzLWxpdmU%3d#AN5RN613152219&db5edsbl>
17. Oliff, H. and Liu, Y. (2017), "Towards industry 4.0 utilizing data-mining techniques: a case study on quality improvement", in *Procedia CIRP*, 63(Manufacturing Systems 4.0 - Proceedings of the 50th CIRP Conference on Manufacturing Systems), pp. 167-172, doi: 10.1016/j.p

18. Qin, J., Liu, Y. and Grosvenor, R. (2016), "A categorical framework of manufacturing for industry 4.0 and beyond", *Procedia CIRP*, (The Sixth International Conference on Changeable, Agile, Reconfigurable and Virtual Production (CARV2016), Vol. 52, pp. 173-178, doi: 10.1016/j.procir. 2016.08.005.
19. Singh, R. (2018), 50,000 Malaysians Expected to Be Laid off This Year, January 4, *The Sun daily*, available at: <http://www.thesundaily.my/node/516338>
20. Siti Nur, D.M., Nasri, N.M., Ali Samsudin, M. and Halim, L. (2018), "Science teacher education in Malaysia: challenges and way forward", *Asia-Pacific Science Education*, Vol. 4 No. 1, pp. 1-12, doi: 10.1186/s41029-018-0026-3.
21. Stancioiu, A. (2017), "The fourth industrial revolution, Industry 4.0", *Fiability and Durability/Fiabilitate Si Durabilitate*, Vol. 1, pp. 74-78, available at: <http://eds.a.ebscohost.com/eds/detail/detail?vid53&sid562e3f086-ed23-40f39dd23601cf7c71b5%40sessionmgr4006&bdata5JnNpdGU9ZWRzLWxpdmU%3d#AN5123300383&db5a9h>
22. Sung, T.K. (2018), "Industry 4.0: a Korea perspective", *Technological Forecasting and Social Change*, Vol. 132, pp. 40-45, doi: 10.1016/j.techfore.2017.11.005.
23. Szozda, N. (2017), "Industry 4.0 and its impact on the functioning of supply chains", *Logforum*, Vol. 13 No. 4, pp. 401-414, doi: 10.17270/J.LOG.2017.4.2.
24. Waldrop, M.M. (2018), "Will Robots Take My Job? Quality Digest website", available at: <https://www.qualitydigest.com/inside/innovation-article/will-robots-take-my-job-101518.html>.
25. Wagner, T., Herrmann, C. and Thiede, S. (2017), "Industry 4.0 impacts on lean production systems", *Procedia CIRP*, Vol. 63, pp. 125-131, doi: 10.1016/j.procir.2017.02.041.
26. Williamson, J. (2020), "Augmented reality tipped to be at the heart of new "working normal"", May, available at: <https://www.themanufacturer.com/articles/augmented-reality-tipped-to-be-at-theheart-of-new-working-normal/>
27. Zavadska, Z. & Zavadsky, J. (2018). "Quality managers and their future technological expectations related to Industry 4.0 H", *Total Quality Management And Business Excellence*, pp. 1-25, doi: 10.1080/14783363.2018.1444474.