Document Analysis on Literature of the Industry 4.0 Workforce Requirement

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ABSTRACT

Industry 4.0 Workforce Requirement is a topic being discussed widely in various publications including journals, conference proceedings, reports, blogs and websites. The discussions revolve around the relevance of low-skilled and semi–skilled workforce and their new roles if they are to meet the requirements of Industry 4.0. Some scholars view that low-skilled and semi-skilled workers are no longer relevant, whereas others deem that these workers are still crucial in the Industry 4.0 era. In particular, disagreements on what constitutes workforce requirements for the Industry 4.0 is a contention that is affecting the credibility of research undertaken in the area. Thus, disagreements on workforce requirements need to be addressed and one way to do this is by reviewing and analysing existing literature on it. The aim of this study is to demonstrate the use of the document analysis method on Industry 4.0 workforce requirements literature as a means of enhancing the credibility of a piece of qualitative research. Sixty-two articles and their writings on Industry 4.0 workforce requirements were reviewed qualitatively following Bowen's guidelines of document analysis with the aid of the ATLAS *ti*. software. The findings elicited four main themes of the Industry 4.0 workforce requirements namely, high-skilled, semi-skilled, low-skilled and general requirements providing useful foundational knowledge for researchers. This study demonstrated that the document analysis approach could be used as part of the literature review process to enhance research credibility.

Keywords: Document analysis; Primary literature; Secondary literature; Grey literature; Industry 4.0; High-skilled, Semi-skilled and Low-skilled workers

Article Info:

INTRODUCTION

The world has experienced several industrial revolutions with advances in technology and is currently experiencing its fourth one. The first Industrial Revolution or Industry 1.0, commenced in the 1760s, originating in the United Kingdom and was specific to the manufacturing industry. Industry 1.0 relied on the physical strength and machinery driven by steam power. Later, during the period between 1840 and 1870, the second Industrial Revolution (Industry 2.0) emerged, which was referred to as the 'technological revolution'; where steam power is replaced by the use of electrical energy which leads to better production) In the middle of the 20th century, the third Industrial Revolution (Industry 3.0) began, as electronics and information technology (IT) automation were introduced to the manufacturing sector with the introduction of the first programmable logic controller in 1969 (Kagermann, Wahlster, & Helbig, 2013). From the beginning of the 21st century, the Industry 4.0 revolution emerges as full automation and digitalisation processes in the manufacturing and services of the private sectors were enabled via the use of electronics and IT (Roblek, Mesko, & Krapez, 2016). Wahlster(2016) one of the experts who first introduced Industry 4.0 back in 2011, proposed the ideation of the Cyber-Physical Production Systems.

Since then, there are various concepts of Industry 4.0 were defined by existing scholars. For instance, the concept of Industry 4.0 refers to the "trends in automation and data exchange in the area of manufacturing" (Kuo et al., 2017, p. 45). Similarly, Man and Strandhagen (2017), defined the concept of Industry 4.0 as "technological advancements in digitalisation and automation" (p.721). The technological advancements are driven by nine pillars of Industry 4.0 which are horizontal and vertical system integration, the Internet of Things, cyber security, cloud manufacturing/cloud computing, big data, simulation, additive manufacturing, augmented reality and robotics (Bahrin & et al.,2016).

Despite the multitude of potential technologies applicable in Industry 4.0, not all industries are taking advantage of them. Implementation may depend on many interrelated factors. For example, a study by Dworschak and Zaiser (2014) found that the implementation of Industry 4.0 technologies such as Cyber-Physical System (CPS) is "dependent on the companies' choice of design of technology and work organization" (p.349). Hence, the definition of Industry 4.0 may vary and can include such concepts as cyber-physical systems (CPS), intelligent manufacturing systems (IMS), cyber-physical production systems (CPPS), and smart manufacturing (Pacaux-Lemoine, Trentesaux, Zambrano Rey, & Millot, 2017; Roblek et al., 2016; Schumacher, Erol, & Sihn, 2016). In addition to using advanced technology, Industry 4.0 may also be affecting workforce requirements. Some scholars like Chang et al. (2016) claimed that Industry 4.0 may eliminate the need for low- and semi-skilled workers, whereas Hirsch-Kreinsen (2016) and Pfeiffer (2016) argued that low- and semi-skilled workers remain important in the Industry 4.0 working environment. Nonetheless, with the prevalent use of advanced technology, the higher requirement for high-skilled workers is anticipated in the future productions of the manufacturing sector (Janis & Alias, 2018).

BACKGROUND OF STUDY

The emergence of Industry 4.0 technology, which relies heavily on intelligent automated technology creates an 'uncertain and unstable' environment due to new technology being proposed for use in the existing conventional manufacturing (Shamim et al., 2016). Several factors have been identified as contributors to the 'uncertain and unstable' environment; one of which is the lack of a common definition of Industry 4.0 (Götz & Jankowska, 2017; Mohamed, 2018). This means that the concept is being applied differently by organizations and countries which also could be found in various policy making and strategies. While some countries such as, Malaysia and Germany are using the term namely 'Industry 4.0'(Ministry of International Trade & Industry, 2018; Rojko, 2017); others may use different terms to denote Industry 4.0 in their own country such as 'Made in China 2025' (China) (Zhang & Liu, 2015,p.887), 'Alliance pour I'Industrie du Futur' (France), 'Smart Industry' (Netherlands), 'Produktion 2030' (Sweden), 'Intelligent Factory Cluster' (Italy), 'Connected Industry 4.0' (Spain), 'High Value Manufacturing Catapult' (HVMC) (United Kingdom) and 'Prumysl 4.0' (Czech Republic) (Demetrius Klitou, Conrads, & Rasmussen, 2017). Another factor is the low acceptance and readiness among the manufacturers to adopt Industry 4.0 (Müller, Kiel, & Voigt, 2018). Thus, all these factors contribute to the 'uncertain and unstable' environment.

A shortage of high-skilled workers in the process of transition to Industry 4.0 is another factor that creates an uncertain and unstable working environment (Pfeiffer, 2015). Consequently, the introduction of the Industry 4.0 environment has caused a loss of employment among low-skilled and semi-skilled workers (Balliester & Elsheikhi, 2018; Chang et al., 2016), due to the increased demand for high-skilled workers. Competencies possessed by high-skilled workers such as problem-solving skills, creativity, and decision-making is seen as being more crucial and more suited to the Industry 4.0 working environment (Gehrke & Kühn, 2015; Jaeger et al., 2014; Prifti et al., 2017). However, evidence found in extensive research on competencies and skills suggests that low-skilled and semi-skilled workers remain relevant in the Industry 4.0 working environment. For instance, Hirsch-Kreinsen (2016) found that low-skilled workers can still be relevant as they could perform tasks (related to Industry 4.0) with the use of an assistance system. This finding indicates that operators continue to be important in the human-machine interface application (Tervo & Koivo, 2014). In future scenarios, operators will not only run and monitor the machine performance but should be able to customize machine performance as well (Ansari & Seidenberg, 2016).

Why Document Analysis?

Document analysis is "a systematic, qualitative research method for thematically reviewing papers" (Bekker & Finch, 2016, p. 1). It is "the analysis of any type of document for the purpose of gathering facts" (Pershing, 2002, p.37). Thus, document analysis can be a useful tool for gathering facts and seeing trends in narratives. Bowen (2009) listed five reasons for conducting a document analysis. Firstly, documents are a source of information either within the researcher's research context or from a historical background. Secondly, documents provide suggestions for research questions or interview questions. Thirdly, documents provide supplementary research data. Fourthly, the document can be used to track or monitor the change and development in related research over some period. Fifthly, documents can help to verify findings or corroborate evidence from other sources.

Also, Bowen (2009) and Pershing (2002) shared a similar view on numerous benefits when conducting a document analysis. First, documents are the only way to obtain data and information. Second, documents are easy to read, easier to obtain, and inexpensive. Third, information from document analysis can be more credible and less biased, compared to information obtained from other research methods (such as interviews, field notes, and surveys). Pershing (2002), however, further explained that document analysis is only useful when the readers (for instance; the analysts, evaluators, and researchers) have an idea of what they are interested in analysing or evaluating (p.37). This scenario leads to document analysis being taken for granted sometimes, where quotations are taken to fit research purposes without understanding the real reasons behind the publication itself; which was previously discussed in a study by Roswitha (2009) on the complementarity in the document analysis process.

The document itself is a prime source for validating data and information more quickly and inexpensively compared to other qualitative data analysis methods (Bowen, 2009). In addition to the benefits offered by document analysis, document analysis could also be used in conjunction with other research approaches and methodologies. For instance, Salminen, Kauppinen and Lehtovaara (1997) developed their methodology for document analysis in defining practical document standards for an organisation. In a different research, Cardno and Anderson (2017) introduced a documentary analysis 'hui', as a combination of two traditional methods—documentary analysis and focus group interview with a group of people *(hui* is a Māori word for a social gathering). In brief, the document analysis process allows a researcher to gain information accurately and ascertain the credibility of the sources of information.

Multiple interpretations often exist while reviewing literature as a reader's understanding is created and differentiated based on the research purposes (Agee, 2009). Multiple interpretations, however, may cause misinterpretations and this can happen as suggested by Ulucanlar et al. (2014) who found misinterpretations in scientific shreds of evidence while reviewing the literature. Several issues have been highlighted related to misinterpretation in the research processes such as repetitive misquoting (Boutron & Ravaud, 2018), distortion of main messages (Kirk & Talbot, 1959), use of invalid evidence (Smit, Morgan, & Lagnado, 2018), and other methodological and research issues. Document analysis that is based on best practices can be used to minimize the issues and misinterpretations in the research processes. Although document analysis could be used as a stand-alone data collection method (Pershing, 2002), Bowen (2009), however, suggested that it should be used with other methods (such as observations and interviews) to enhance the credibility of findings. Document analysis is commonly conducted based on the researcher's needs and purpose. However, the researcher's needs and purpose may cause bias in document selection and sometimes, quotes are taken and interpreted differently from the main purpose of written publication as claimed by Ulucanlar et al. (2014). Meanwhile, from the publication's perspective, the publication is commonly written according to the organisation's requirements. Bowen (2009) explained that this happens because different organisations have different publications, and are aimed at different target readers. In brief, document analysis must be used with careful thought to avoid less-than-credible findings.

Similarly, multiple interpretations of Industry 4.0 workforce requirements can be elicited from the diverse Industry 4.0 publications which could significantly influence the direction of research and its process. Document analysis in Industry 4.0 publications is useful for gaining insight into a research problem, which contributes to the construction of good research questions. Agee (2009) in her reflection process of developing qualitative research questions pointed out Coiro and Dobler's (2007) research work as an exemplar of using a literature review to develop research questions. She further stated that the research requires sufficient materials to demonstrate grounded processes (such as research interest, theoretical premises and related issues) all of which consequently guide the research questions' development process; which in this study, the credible source of the Industry 4.0 publication contributes to the corresponding author's literature review process.

Based on the Industry 4.0 publications, each person has a different interpretation of the Industry 4.0 workforce requirements. For example, some technical experts might consider low- and semi-skilled workers as necessary as high-skilled workers, whereas other experts may think that low- and semi-skilled workers could be replaced by Industry 4.0 technology. Different types of readers may have different interpretations. Readers (such as Ph.D. students, company managers, business consultants, technical experts such as engineers or technicians, professors and researchers from academic institutions, and the wider public) approach research with different purposes and might have interpreted the Industry 4.0 concept from different views and perceptions. Thus, it is necessary to use document analysis in exploring the Industry 4.0 workforce requirement.

Apart from being integral to the literature process, document analysis also contributes to the corresponding author's data collection. During the document analysis process, the documents were used "to verify findings and corroborate evidence from other sources" as suggested by Bowen, (2009, p.30). Despite its usefulness to its ability to increase the credibility of research, the use of document analysis has not been found to be prevalent and is especially limited in the area of workforce requirements, for low-skilled and semi-skilled workers which is yet to be fully understood.

The purpose of this study is to demonstrate the use of document analysis in the literature on workforce requirements in Industry 4.0. Specifically, the central research question for this research is: how do we identify workforce requirements in the Industry 4.0 using a document analysis?

METHOD

The document analysis was conducted with the aid of ATLAS ti. software. The ATLAS ti. software is used in this study as it provides a transparent process in data analysis, and therefore, the document can be analysed more effectively. This software is one of the Computer Assisted Qualitative Data Analysis Software (CAQDAS) that can enrich the analysis process. Methodologically, the quotation from each document is coded using 'in-vivo code' to preserve the meaning and to avoid researcher bias in data analysis. However, in certain scenarios such as if the information is too long to code or to avoid redundant codes during the coding process, the 'open code' and 'list code' were also used in the coding process. The coding procedure was conducted according to Bowen's (2009) description of the specific uses of documents (p. 30), as follows:

Purpose 1: Understand the purpose of the document—the reason it was produced

Purpose 2: Know the target audience

Purpose 3: Know the author of the document

Purpose 4: Know the original sources of information

Purpose 5: Know whether the information is first-hand experience or from secondary sources

In this study, 62 articles were obtained from the corresponding author in her previous research work in document analysis to identify the Industry 4.0 competencies requirement for high-skilled, semi-skilled and low-skilled workers (Janis, 2019). The 62 articles were analysed to understand the emerging trend of Industry 4.0 during the first year of the corresponding author's Ph.D. study back in 2017. The 62 articles contain several keywords such as Industry 4.0, high-skilled, semi-skilled and low-skilled workers. Unlike the systematic literature review that is aimed to identify, evaluate and integrate the findings (Siddaway, 2014), document analysis in this study, however, is used as a systematic procedure to review and evaluate documents (Bowen, 2009). The "nature and form of documents" of each article in this study were reviewed and assigned with ID codes such as D1…D62 (Bowen, 2009, p.27). The source of publication is defined as a conference, journal, and report, or magazine which is later classified into four main types of literature namely primary literature, secondary literature, tertiary literature and grey literature. However, in this study, there is no tertiary publication identified in the Industry 4.0 publications and thus, the document analysis was only conducted for primary literature, secondary literature and grey literature.

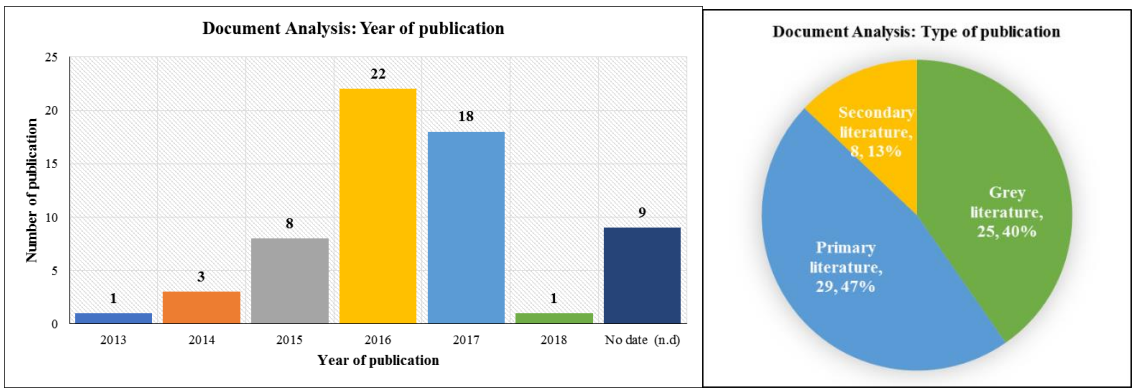

Figure 1: Year of publication and type of publication in document analysis

Figure 1 shows the distributions of publications according to the year published for the 62 articles. An increasing trend of publications is seen from 2013 until 2017 when the concept of Industry 4.0 is being introduced. Also, there are a few numbers of undated publications identified (9 articles). There are three identified types of publication; where the highest number of publications is the primary literature (29 articles, 47%), followed by the grey literature, 25 articles (40%) and the secondary literature (8 articles, 13%).

DATA ANALYSIS AND FINDINGS

Figure 2 shows the distributions of publications for primary and secondary literature. Primary literature in this study refers to publications where the author can report their personal experiences or research work which is often written by an expert or graduate student in the research field (Florida Gulf Coast University Library Services, 2005). Based on data analysis, the highest number of primary literature is from conference proceedings (21 articles) whereas only three articles were identified for the journal. Also, data analysis reveals five articles (report publication) that contain research methodology and thus, these publications are classified as primary literature.

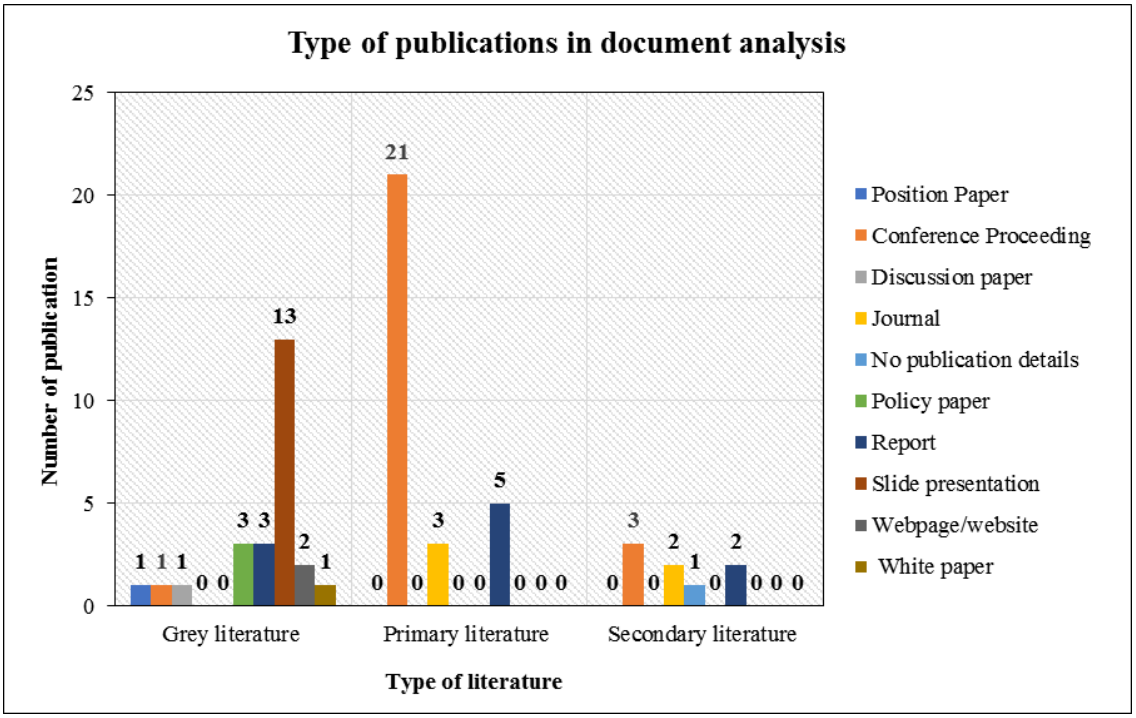

Figure 2: Type of publication according to primary literature and secondary literature

Meanwhile, the secondary literature in Figure 2 shows the number of publications; conference proceedings (3 articles), both journals and reports (2 articles) and 1 article but no details of publication. The secondary literature refers to the publication that was written based on primary sources (Florida Gulf Coast University Library Services, 2005). The grey literature in Figure 2 shows the highest number of publications is the slides presentation that is obtained from the conference proceeding, business consultant and academician's presentation. Followed by a policy paper and report (3 articles), 2 articles obtained from a webpage or website and 1 article from each type of publication; position paper, conference proceeding that has no details of publication, discussion paper and white paper. The journal and article (that has no publication details) were none identified in the grey literature.

 ISSN no: 1823-8521

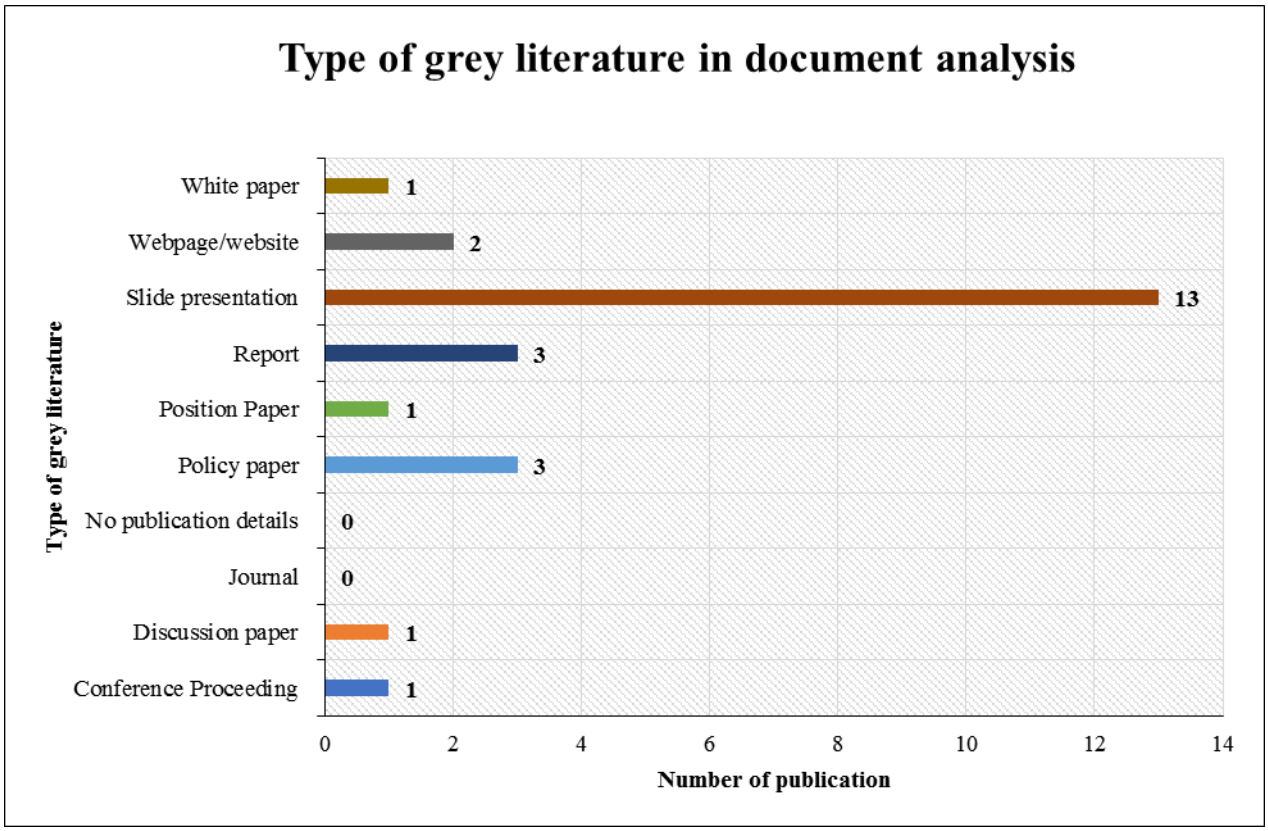

Figure 3: Type of grey literature in document analysis

Figure 3 shows different types of grey literature that contain information related to the Industry 4.0 workforce. The highest number of grey works of literature are slide presentations (13 articles) that could be obtained easily from a web search. The slide presentations consist of the conference proceeding slides presentation, the business consultant such as FESTO, followed by the policy paper (3 articles), web page or website (2 publications), report such as KPMG report, CAPGEMINI report and conference report (3 articles) and 1 article for each type of publications such as white paper, position paper and discussion paper, and conference proceeding that does not contain details of publication. Although the grey articles were not preferable used in academic writing, it can provide a balanced view of the evidence (Paez, 2017).

Methodologically, the solo-coding process was conducted by using inductive coding – which began by identifying the research objective, the type of the articles, the source of information and the research methodology used as suggested by Bowen (2009) and Altheide et al. (2001) guidance in conducting qualitative document analysis. The selected quotations were associated with the research purpose – to understand the Industry 4.0 workforce requirement.

Figure 4 illustrates the manual inductive-coding process: first cycle and second cycle coding process. The in-vivo code, open code and list code were used in this inductive coding process. The open code or also known as 'initial code' is used as "a starting point to provide the researcher with analytic leads for further exploration" (Saldana, 2009, p.81). In the first cycle coding process, open codes were applied to the document and assigned with a pseudonym as D1, D2, D3…D62 (which means the number of documents that has been reviewed), the in-vivo code or open code for research aim or the research objective, type of documents (i.e. journal, conference proceeding, business report, etc.), the source origin (i.e. university, business, consultation, and industry), the review or publish result that is obtained either from interview, survey, observation and other methods, and Industry 4.0 workforce requirement (i.e. high-skilled, semi-skilled, low-skilled and general requirements). The coding process is repeatedly conducted in the following documents and the identified same codes such as (type of documents – journal, conference proceeding, etc.) from the previous coding process are assigned as the 'list code'.

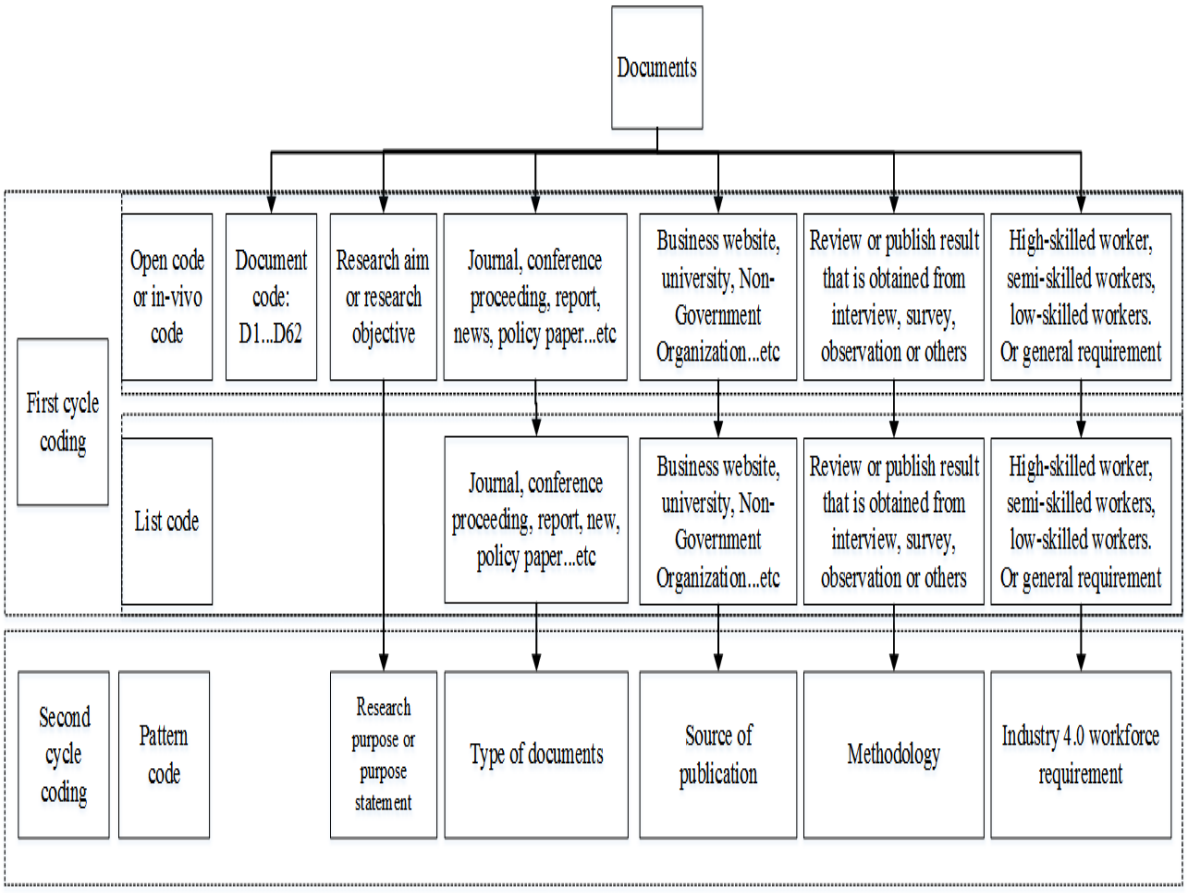

Figure 4: The manual inductive coding process

The 'list code' is one of the code features introduced in the Atlas *ti*. software that is used as a template for the whole coding process. The list codes are used to avoid redundant open codes during the coding process. The similarities of codes later are identified as pattern codes in the second cycle of the coding process. The purpose of using a pattern code is to "… identify an emergent theme, configuration, or explanation" (Saldana, 2009); which resulting the research purpose or purpose statement of the document, type of documents, and source of publication (which refer to the origin of research conducted), methodology (which indicates the type of publication either primary literature, secondary literature or grey literature) and the Industry 4.0 workforce requirement (which refer to the aim of this study).

Figure 5 illustrates the example of the inductive-coding process by using the ATLAS *ti*. software. The first reviewed document is defined as D1. The green dotted lines refer to conducted research methodology – focus group interview and systematic literature review. The articles that contain research methodology, are later defined as primary literature which is indicated by a straight line with a single-ended arrow (indicates D1 as primary literature). D1 refers to several quotations from Prifti et al. (2017), who proposed a competency model for Industry 4.0 employees. For instance, Prifti et al. (2017) mentioned her research aim – "This paper analyses employee competencies for employees with higher education in Industry 4.0" (p.46). The Industry 4.0 workforce requirement is further analysed to Prifti et al. (2017) concern on the Industry 4.0 workforce requirement where she mentioned several roles such as engineers and IT professionals that are associated with high-skilled workers. Then, the in-vivo code of 'conference proceeding' is defined and linked to the source of publication; which is University (indicated by a dashed line with a single-ended arrow (refer to the conference proceeding from the University). The year of publication - 2017 is later identified.

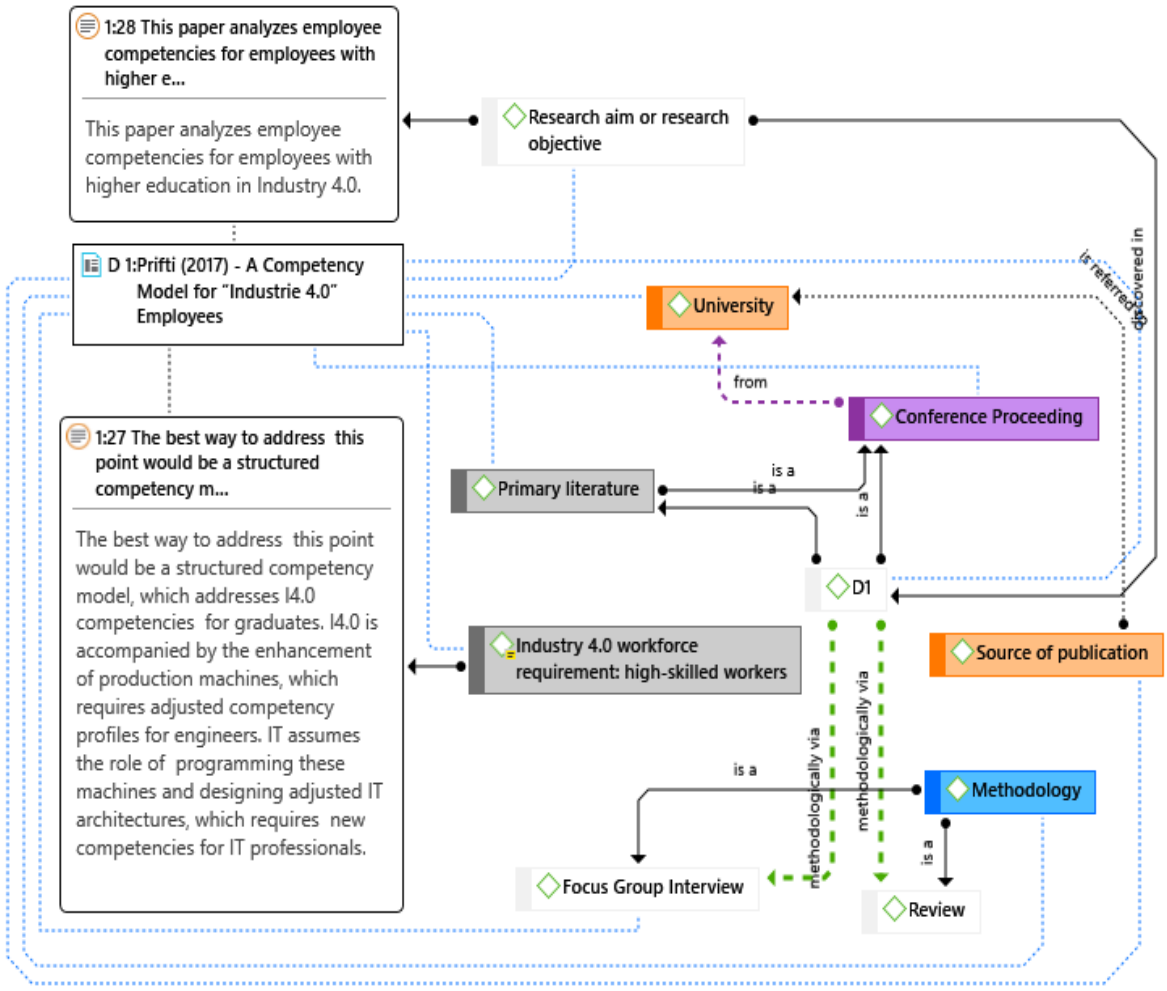

Figure 5: The example of the coding process in ATLAS *ti.* software

The summary of the coding process in reference to the document analysis procedure is described in Table 1.

Specific uses of documents	Proposed document analysis procedure	Example of Coding Process
Understand the purpose of the document – the reason it was produced	Identify the issues Identify timeline – years of publication	Industry 4.0 competency model proposed by Prifti et al. (2017)
Know the target audience And author of document	Know the author's information and his/her target audience	Conference Proceeding University
Know the original sources of information	Identify types of literature –i.e. primary literature, secondary literature, tertiary literature or grey literature	Primary literature– conduct systematic literature review and focus group interview to ascertain the findings from the systematic literature review
Know whether the information is first-hand experience or from secondary sources	Define the purpose of documents – such as purpose of statement, executive summary, aim of the project experimental or objective of the publication to identify whether data is obtained from first-hand experience or from secondary sources	Based on methodological approaches which are first-hand experiences and therefore document is defined as primary literature

Table 1: The proposed document analysis procedure in reference to Bowen's specific uses of documents and example of the coding process

Based on the coding process, there are four themes emerge from the Industry 4.0 publications as illustrated in Figure 6. For Industry 4.0 workforce requirements, there are new workforce requirements for high-skilled workers, new workforce requirements for semi-skilled workers, new workforce requirements for low-skilled workers and workforce requirements in general were identified. The workforce requirement in general means the publication does not mention specifically the role of high-skilled, semi-skilled and low-skilled workers in regard to the Industry 4.0 workforce requirement.

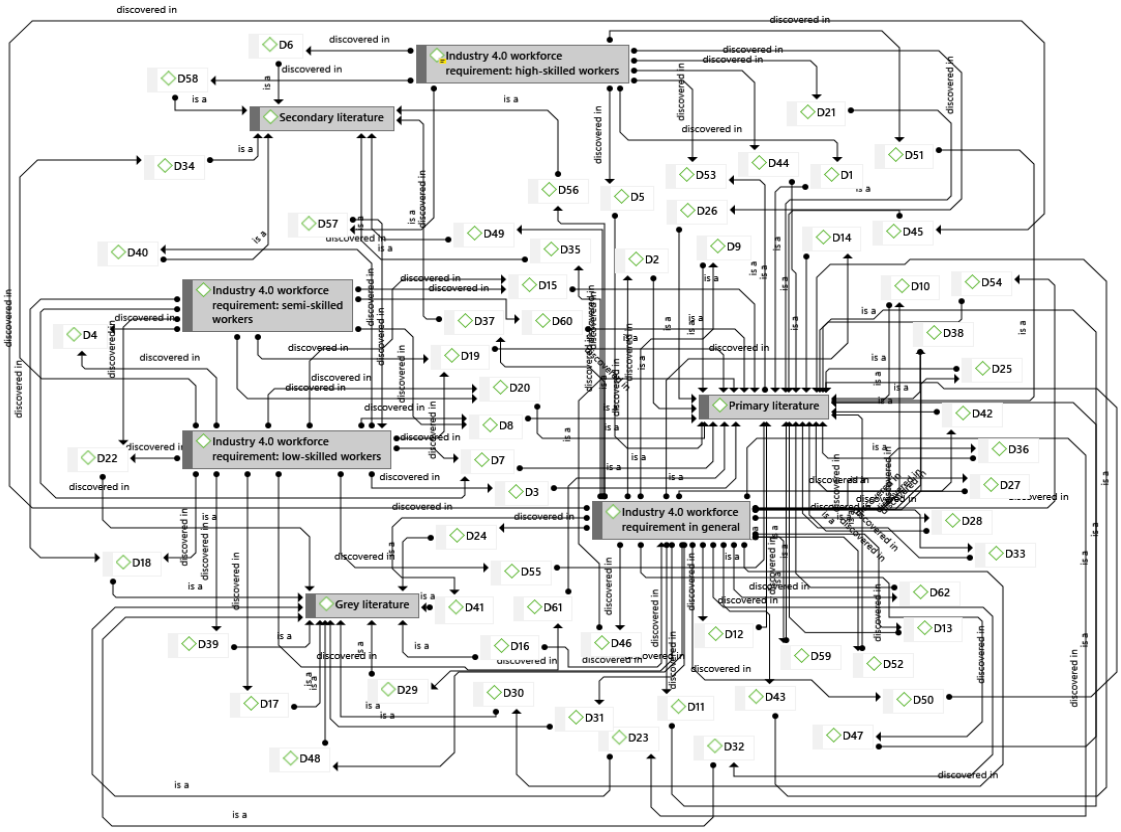

Figure 6: The emerging themes of the Industry 4.0 workforce requirement in the ATLAS *ti*. Network view

Afterward, each theme was defined based on the similarities of the Industry 4.0 workforce requirement that is obtained from various types of Industry 4.0 articles which were coded as D1…until D62 as shown in Figure 6; that was distinguished by types of literature (primary, secondary and grey literature). The source of information for each theme was verified based on the first-hand information obtained from the methodological approach. There are three methodological approaches identified and described as the first-hand information which are i) the conceptual or theoretical framework ii) experimental including system simulation and Learning Factory/Teaching Factory and iii) interview, observation, survey, case study or assessments. These methodological approaches were used to distinguish the publication (either first-hand information or secondary) to identify the type of literature (primary, secondary and grey literature). The secondary information refers to the secondary literature such as a review paper, systematic literature review, or critical review; whereas, the grey literature refers to the publications that do not mention the research approach or methodology.

Based on the emerging themes of the Industry 4.0 workforce requirement in Figure 6, the pattern code of the Industry 4.0 workforce requirement in general, high-skilled, semi-skilled and low-skilled workers also can be further explained in the graph shown in Figure 7. For grey literature, the highest number of publications were identified discussing the 'Industry 4.0 workforce requirement in general' (21 articles), followed by the low-skilled workers (3 articles), 1 article for the Industry 4.0 workforce requirement for high-skilled worker and none publication identified for semi-skilled worker.

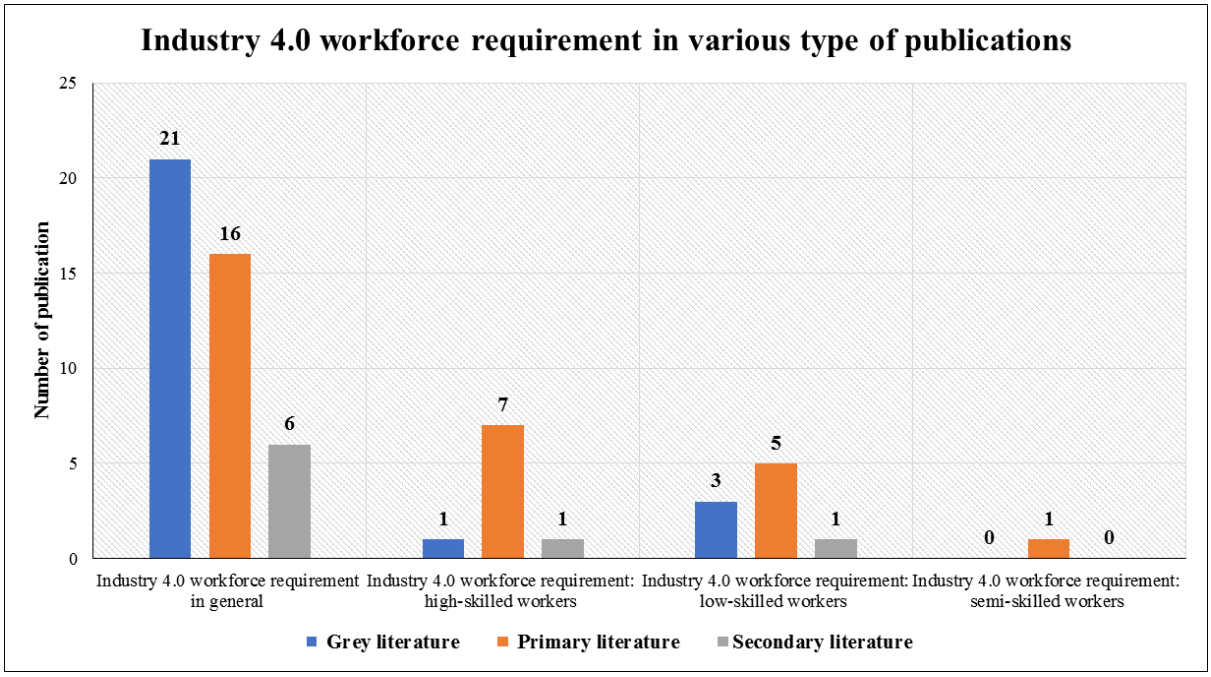

Figure 7: Industry 4.0 workforce requirement in various types of publications

Meanwhile, primary literature that consists of journals, conference proceedings, and reports show that the highest number of publications on the Industry 4.0 workforce requirement goes to the 'Industry 4.0 workforce requirement in general' (16 articles), high-skilled workers (7 articles), low-skilled workers (5 articles) and 1 article for semi-skilled workers. Then, for the secondary literature which consists of journals or conference proceedings; the highest number of publications goes to the 'Industry 4.0 workforce requirement in general' (6 articles), and 1 article found in both high-skilled and low-skilled workers. Meanwhile, no publication was identified for the semi-skilled workers.

DISCUSSION

The findings indicate four workforce requirements for Industry 4.0 which are, for high-skilled workers, semi-skilled workers, low-skilled workers and general workers. For the high-skilled workers, the findings reveal that workforce requirements for this cluster group are mostly mentioned in the primary literature. The Industry 4.0 workforce requirement are identified via i) empirical data from conceptual framework/model/approach ii) empirical data from the interview, observation, survey, assessment, or case study iii) empirical data from Learning Factory, Experimental, Simulation and System. For example, Jaeger et al. (2014) and Prinz et al. (2016) were conducting research to identify new competencies and skills requirements for the engineer; meanwhile Krugh et al. (2017) and Richert et al. (2016), were focusing on the need for integration between humans and machines in the Industry 4.0 working environment. Also, data analysis reveals several publications such as a report that contains methodology which could be classified as primary literature.

Secondly, for the semi-skilled workers, the findings reveal that there is little to none of the Industry 4.0 literature discussing the workforce requirement for this cluster group. There are two reasons for a few publications of the Industry 4.0 literature discussing the semi-skilled worker. The first reason is, some scholars regarded the terms of semi-skilled workers as high-skilled workers. For example, Beaudry, Green and Sand (2013) stated that the skilled employee or skilled manufacturing personnel referred to engineer or professional level. The second reason is, some scholars do not mention the role of semi-skilled workers. For instance, Dworschak and Zaiser (2014) findings on the "automation scenario", that the autonomy of skilled workers is limited whereas high-skilled employees are responsible for the installation, modification and maintenance of Cyber-Physical System (CPS) (Dworschak and Zaiser, 2014).

Furthermore, throughout the literature, the definition of shop floor workers or production worker is not fully justified (Jaeger et al., 2014; Prinz et al., 2016) as there are few terms of "semi-skilled" and "skilled" were interchangeably used in the existing literature. For example, according to Rothwell (2015) definition, the middle-

skilled may define as a skilled technical worker, which requires vocational certificates (Pfeiffer, 2016; Rothwell, 2015). Meanwhile, (Sulaiman, 2017) research claimed that the occupation of technical is referred to as middle-skilled (or semi-skilled). Also, data analysis reveals that the publications for semi-skilled workers are mostly obtained from journals and conference proceedings and few to no publications are found in secondary literature and grey literature.

Thirdly for the low-skilled workers, the finding reveals that the low-skilled worker (such as a production workers in the manufacturing shop floor production) are mostly mentioned in primary literature but less mentioned in the secondary and grey literature. Nonetheless, the identified grey literature widely discusses the possibility of unemployment among low-skilled workers. For instance, the discussion paper by Ng (2017) states, 'it is estimated that more than half of all current jobs in Malaysia are at high risk of being affected by automation in the next one to two decades' (p. 3). Meanwhile, in ASEAN (transformation research) written by Chang et al. (2016), it was claimed that technologies may "render some occupations obsolete and create new ones" (p. xv). Furthermore, Benedikt Frey et al. (2013) had previously discussed the unemployment caused by data and computerisation.

Despite a significant amount of grey literature saying that the technologies within Industry 4.0 may lead to disruptive employment, by contrast, in the primary literature, Hirsch-Kreinsen (2016) claimed that low-skilled workers are remaining important in shop floor production. His acclamation became a valuable input to policy making in terms of employment policy and social democracy in Germany. Further, the Hirsch-Kreinsen's acclamation is supported by academics who consider that competencies and skills requirements are dependent on the individual work organisation. Dworschak and Zaiser (2014) further explained that "the factual skill needs in CPS will be dependent on the companies' choice of design of technology and work organization" (p. 349). Also, several examples could be seen in the existing literature such as Pacaux-Lemoine et al. (2017), who discovered the aspect of human operators from the early stages is required in the design process to adopt the more human-centred approach and Nelles et al. (2016), who emphasized that the role of humans in Industry 4.0 via the proposed human-centred design of assistance systems remained important.

Being a decision-maker in production planning and control could be one key human role in the Industry 4.0 working environment. One of many examples (how Industry 4.0 is integrated with humans) is further explained by Schleipen et al. (2016), where the operator is observed to use the tablet app connected to a barcode scanner to simplify information acquisition. Similarly, Liu and Xu (2017) described how the proposed cyber-physical production system may reduce the human effort requirement as field-level devices are autonomously co-operated. Also, Krugh et al. (2017) in their research that is related to human workers online in Industry 4.0 manufacturing and contribute to the understanding of the human worker. Hence, considering the similar view of these various scholars were evident that the human role remains important in the Industry 4.0 working environment. Further, Industry 4.0 research that involves modelling, systems, experiment, simulation, or prototypes usually emphasises the human role and their contribution to Industry 4.0.

Fourthly for the Industry 4.0 workforce requirement in general. Most of the publications (either of primary, secondary or grey literature) discuss the workforce requirement in general and not the specific job profile (such as engineer, technician or production operator). Most of the grey literature discusses the concept of Industry 4.0 and the workforce requirement. For instance, the reports that are written by business consultancies (such as McKinsey, The Boston Consulting Group, Deloitte Report, and ACATECH) commonly viewed the workforce requirement from the human resources perspective. The human resources perspective may view the workforce requirement differently in comparison to the technical personnel's perspective. For instance, from the lens of human resources perspective, the low-skilled workers could be replaced by the use of automation; by contrast, the production people (for instance, engineer or training department) may view the low-skilled workers as important personnel in the shop floor production and vice versa.

Furthermore, the 'Business and Research Consultant' reports mostly discuss the disruptive employment that is caused by Industry 4.0. For example, McKinsey and Company (2015) report, introduced collaborative robots to increase labour productivity in the manufacturing plant. Labour is an important cost driver in most industries and therefore, collaborative robots may allow humans and machines to work in close proximity to each other without risking injury to the workers. Meanwhile, the World Economic Forum (2017) also reported many blue-collar jobs in manufacturing have disappeared including white collar in many traditional jobs due to new technology adoption. The robot trend is predicted to replace human manual routine tasks (Lee & Wie, 2015) but argued by Hirsch-Kreinsen, (2016) and Pfeiffer (2016), believed that the new job would be created to assist the robot function

in the manufacturing and service sector and thus, the low-skilled and semi-skilled workers remaining important in the Industry 4.0.

CONCLUSION, LIMITATION, AND RECOMMENDATION

Significantly, the document analysis process enhancing the credibility of the literature review process, as well as ascertaining the credibility of sources of information of the Industry 4.0 workforce requirement. Conducting document analysis in the ATLAS *ti.* software allows the literature review process (by means of type of document and information related to Industry 4.0 workforce requirement) to be conducted transparently; as the ATLAS *ti*. software allows the researcher to understand the emerging themes based on the ATLAS *ti.* Network view and descriptive analysis (by means of graph or pie chart). The findings also discover some of the grey literature containing the methodological approaches that could be used in ascertaining the Industry 4.0 workforce requirement. Therefore, some of the grey literature is clustered as primary literature and it is credible to be used as a reference for the Industry 4.0 research. However, there are other types of grey literature such as consultant reports, workshop reports, government websites, Non-Government Organization (NGO) websites and reports, position papers and Industry 4.0 supplier reports that do not mention the methodological approach yet briefly discuss the Industry 4.0 workforce requirement, and these remained grey literature due to no mention of methodological approach.

There are a few limitations found in document analysis. Firstly, the methodological approaches (empirical data obtained from a conceptual framework/experiment/interview, etc.) vary according to the research purpose, thus, careful consideration in distinguishing the first-hand information or secondary information is required. Secondly, document analysis, is sometimes misinterpreted as textual analysis. The main difference between these two types of analysis is that document analysis usually refers to the purpose of the published document, while textual analysis is more focused on the content. Thirdly, theoretically, document analysis is a straightforward procedure (read and interpret); however, the coding process could be a barrier in the document analysis process. Therefore, the different stages in the coding process need to be well understood. For a novice user of Atlas *ti.* software, it might be difficult to conduct document analysis without knowledge to use the ATLAS *ti.* and coding method. Fourthly, the graphic illustration in the ATLAS *ti.* Network view can become a barrier when there are too many codes to define. The complex network view may cause difficulties for readers to understand the concept map generated by the ATLAS *ti.* software.

Following that, there are a few recommendations to conduct document analysis effectively. First, it is highly recommended to represent each link (document code to quotation) and its relation with different colours. This is to ease the reader to identify the first-hand or secondary information by understanding the relations between the codes, quotations, to emerging concepts and themes. Second, the inductive coding process in document analysis must include several pieces of information such as the author's information, reason for publication, target audience, and date. The publication date must be written in chronological approach so that the reader understands the timeline of the studied research areas. The chronological timeline is important to understand the latest issue and challenges related to Industry 4.0. Third, document analysis allows the researcher to understand more specifically upon the reason of publication by studying the research purpose, type of document and their audience target (public, academician, Industry 4.0 customers). Hence, the literature review process becomes more credible.

DECLARATION STATEMENT

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ACKNOWLEDGEMENT

We would like to thank Universiti Tun Hussein Onn Malaysia for their support of this paper.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in this study.

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