Vol. 05, No. 4 (2023) 759-766, doi: 10.24874/PES05.04.018

Proceedings on Engineering Sciences

www.pesjournal.net

DIGITAL INTELLIGENCE IN THE AGE OF ARTIFICIAL INTELLIGENCE

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Received 27.03.2023.
Accepted 24.08.2023.
UDC – 004.8

Keywords:

Digital intelligence, artificial intelligence, quality, systems, systematic review

A B S T R A C T

This systematic review examines the current state of digital intelligence in the age of artificial intelligence. A total of 26 relevant papers were shortlisted for a review based on a keyword search of academic databases. The review looked at the literature relating to the fields of artificial intelligence, machine learning, deep learning, and other related fields to understand the current advances in digital intelligence. It considers the impact that digital intelligence has had on society in terms of economic, political, and social implications. The review also considers potential ethical concerns related to digital intelligence and its use in the age of artificial intelligence. Systems utilising artificial intelligence can benefit from considering its impact and digital intelligence and vice versa. This can lead to better quality systems.

1. INTRODUCTION

Artificial Intelligence (AI) is the capability of a machine to mimic humans. An extensive discussion on AI, Stamova and Draganov (2020) provides many useful points. Depending on the type of environment in which they are offered, artificial intelligence services can generally be grouped into two main groups: (1) Services provided in a virtual environment, so-called virtual artificial intelligence services, and (2) Services provided in a physical environment. According to the type of artificial intelligence-based systems.

AI services can be classified as software-based services (e.g., Virtual/digital assistants and chats - Apple Siri, Alexa Amazon, Microsoft Cortana, Google Now, Azure Bot Service, Watson Virtual Agent), and services embedded in hardware devices such as those provided by smart robots. Depending on the field of application, smart robots can be classified as- industrial robots, intelligent auxiliary robots, security and surveillance robots, intralogistics robots, educational robots and more and those provided by autonomous vehicles - autonomous cars, and autonomous subway.

Digital intelligence (DI) is the capability to understand and use technology in order to successfully navigate the modern digital world. It involves the ability to acquire and apply new knowledge and skills in order to understand the changing digital landscape, from the use of social media to mobile applications, analytics to cloud computing, and beyond. DI enables individuals to face the challenges and demands posed by the digital world and to adapt to them. Digital intelligence is not just about using digital tools instead of human capabilities; it is about recognizing the advantages of both people and technology and how we can utilize them for the most benefit.

In businesses, DI is used to refer to the information obtained through technologies and making use of them as an online marketing strategy. DI consists of eight

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areas: Digital identity, Digital rights, Digital literacy, Digital use, Digital communication, Digital safety, Digital emotional intelligence, and Digital security. Within the eight areas, there are three maturity levels classified as level 1 - digital citizenship, level 2 - digital creativity, and level 3 - digital competitiveness. Thus, there are 24 digital competencies. Digital citizenship itself has eight key areas. The DQ Institute has published a framework for digital intelligence (DQInstitute, 2021).

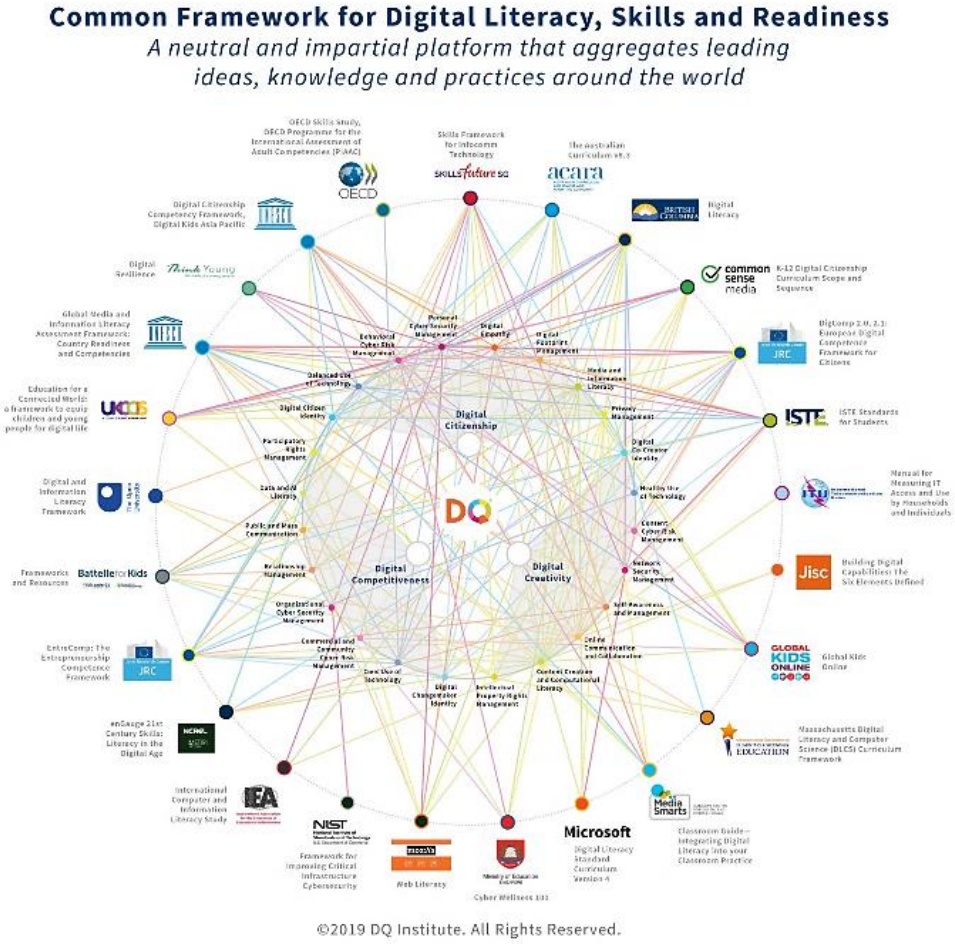

Figure 1. DQ Framework (DQ Institute, 2021)

Having discussed briefly AI and DI, it is time now to examine how DI is connected to AI. This paper answers this question using a systematic review of the literature.

2. METHOD AND RESULTS

Papers published in English on the relevant topics related to DI in the age of AI were collected using appropriate search terms (‘digital intelligence’, and ‘artificial intelligence’) in SCOPUS, EBSCO and WoS databases. The screening selection of papers was done using the PRISMA framework, which is shown in Figure 2. Finally, 26 papers were selected. These papers were arranged into various sections and discussed below.

2.1 General

In business, DI means synchronisation of IT with business strategies as a two-way process. Various steps to do this were explained by Mithas and McFarlan (2017). AI facilitates this process.

In an editorial for the inauguration of a new journal, Kaynak (2021) commented that the most recent development in the application of technologies is the integration of AI with DI as the primary enabler and the facilitator.

According to Verganti, Vendraminelli, and Iansiti (2020), the digital technologies available in AI can be used for increasing innovation capabilities and efficiencies. Design and innovation theory was used for explanations, especially, regarding problem-solving.

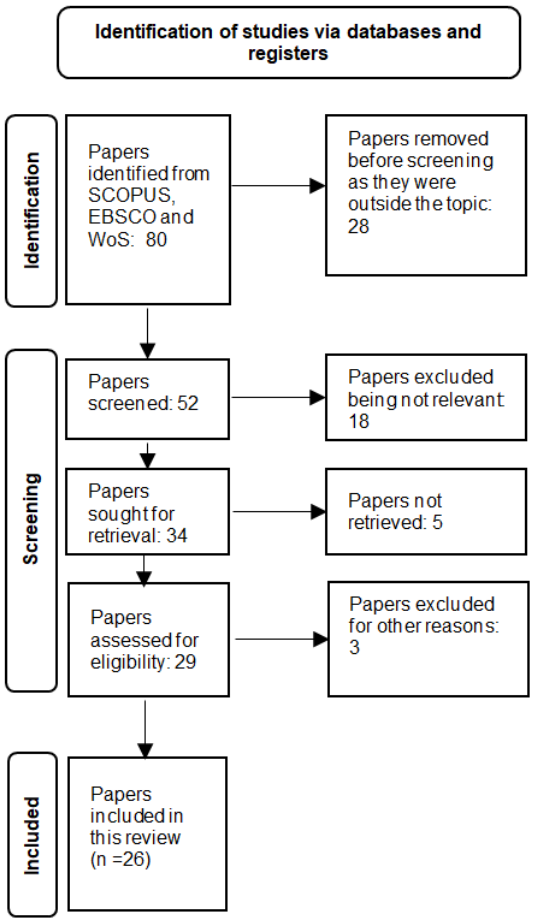

Figure 2. PRISMA Diagaram

Ågerfalk (2020) studied the impact of AI on digital practices formulated as an IS problem of understanding digital agency. Through their semiotic symbol processing capability, IS systems, as digital actors, can perform social action on behalf of humans and organisations. Therefore, information systems need to be designed to manage not only decontextualized data, but also symbols with social significance. These symbols must be collected, stored, modified, and distributed by the information systems. An IS system is an active mediator of social actions. The part of the delegation and autonomous performance is now done by AI. Machine learning is integrated into the current information systems. Behavioural practices in the messaging context are part of the information system. Machine learning is an automated action. In social theory, agency traditionally defaults to human agency. The digital agency is the capability of machines to act autonomously on behalf of humans, organisations and institutions. A digital agency does not presuppose consciousness in the traditional sense. Instead, the accountability of social actions performed by information systems becomes critical. Digital technology requires a different approach in order to be fully utilized. Instead of seeing it as just a means of transmitting information or storing data, we should recognize its potential as an active mediator of communication and interaction. This calls for an ontological shift to "digital first" thinking. IS are actively participating in and shaping reality. A digital transformation is occurring, in which automated processes based on machine learning are generating institutional facts. This necessitates a complete re-evaluation of institutionalisation, and the concept of digital agency is at the heart of this new understanding.

2.2 Business

Gerbert, Justus, and Hecker (2017) noted that AI has reframed the traditional sources of competitive advantage like strategic positioning and capabilities. With the availability of free AI software with self-thinking algorithms, firms need not possess large databanks. Instead, they can build, access and leverage shared, rented or complementary data even by collaborating with competitors to create their own privileged data zone. The principle is to act where others do not. AI can also improve customer access in many ways. AI increases dynamic capabilities also. In all these cases, the use of AI facilitates doing traditional jobs better and thus produces improved outcomes. Four areas in which AI can create durable and significant advantages are customer needs, technological progress, data sources and decomposition processes.

According to Akyüz an Mavnacıoğlu (2021), AI can be effectively used for various marketing activities in the following manner.

Voice processing technologies: e.g., virtual assistants such as Siri supporting task execution.

- Text processing technologies: e.g., a virtual assistant entrenched in a mobile bank application making use of NLP to handle customer complaints by answering their inquiries.
- Image recognition and processing: e.g., as Estée Lauder does, using customer's facial images to find the right colours during online cosmetic shopping.
- Decision-making: e.g., Netflix recommends new shows or a chatbot prepares a cocktail recipe based on the customer's preferences and the ingredients he has at home.
- Autonomous robots and vehicles: e.g., Amazon goes application offers a check-out-free experience to its customers.

In the case of financial services, AI is useful for better customer service management, risk management, credit decisions, and fraud prevention.
AI renders decision-making in organisations easier and more rational, as it uses a large volume of data for this purpose. A framework was proposed by Shrestha, Ben-Menahem, and Von Krogh (2019) integrating AI and human decision-making factors. When creating a combination of human and AI decision-making systems, managers should bear in mind the exact nature of the

decision-making process, the comprehensibility of the decisions and results, the number of available alternatives, the rate of decision-making, and the potential to replicate the decisions. There is a risk of wrong decisions due to input data characteristics in AI. So, complete dependence on AI decisions needs to be avoided. Organisations must develop their own capabilities to make decisions regarding the data being fed into AI algorithms, the algorithms themselves, and how to interpret the AI's predictions. They must also assess both the advantages and disadvantages of AI to ensure they get the most out of the technology.

In this digital era, the strategic use of AI has been a topic of considerable attention. However, due to inadequate knowledge, its implementation has been a problem. Borges, Laurindo, Spínola, Gonçalves, and Mattos (2021) suggested a conceptual framework built on a thorough examination. In addition, they suggested four sources of value creation, which are (i) decision support; (ii) customer and employee involvement; (iii) automation; and (iv) new products and services.

To examine investment in artificial intelligence (AI), to describe how it is being implemented by companies that have started to use these technologies across sectors, and to explore its potential to become a major business disrupter, Bughin, et al. (2017) analysed the total investment landscape bringing together both investment of large corporations and funding from venture capital and private equity funds. A review of the portfolio plays of major internet companies, an evaluation of the dynamics in AI ecosystems from Shenzhen to New York, and a wide range of case studies was done. A survey of more than 3,000 senior executives was done on the use of AI technologies, their companies' prospects for further deployment, and AI's impact on markets, governments, and individuals. The resources of McKinsey Analytics, a global practice that helps clients achieve better performance through data, were also used. The research was conducted jointly with Digital McKinsey, a global practice that designs and implements digital transformations. Digitisation was found to be the basis of AI. Leading sectors in digitisation are also leading sectors in AI. AI has the potential to accelerate shifts in market share, revenue, and profit pools, all of which are related to digitally disrupted sectors.

Based on case studies and the results of two global surveys among senior managers across industries, Brock and Von Wangenheim (2019) showed that AI is typically implemented and used with other advanced digital technologies in firms' digital transformation projects. The digital transformation projects in which AI is deployed are mostly in support of firms' existing businesses, thereby demystifying some of the transformative claims made about AI. A framework was presented for the successful implementation of AI in the context of digital transformation, offering specific guidance in the areas of data, intelligence, being grounded, integrated, teaming, agility, and leadership.
Aimed to support higher education institutions to build curricula for meeting the market demand for qualified human capital to face the challenges of Industry 4.0, Cantú-Ortiz, Sánchez, Garrido, Terashima-Marin, and Brena (2020) undertook a review of the literature and a case study of Tecnologico de Monterrey (Tec). The strategy consisted of a business intelligence summary of AI trends and challenges of interest to these institutions stressing intelligent human-computer communication and interactive design and manufacturing for educating engineers for the future enterprise. The components of the case study were graduate and undergraduate courses, research, internships, innovation, internationalisation initiatives, and entrepreneurship. During this period, more than 5200 students were trained at the PhD, MSc, and undergraduate levels with intense use of technology in the AI field. Based on the results, the curricula of the university have been overhauled and renewed according to this model known as the Tec21 Educative Model.

2.3 Healthcare

In a review paper, Limketkai, Mauldin, and Manitius (2021) discussed how data collected from patients using digital technologies like mobile or wearable devices, can be inputted into AI systems for analysis leading to evidence-based healthcare decisions.

Digital health technologies that incorporate AI have been transforming healthcare delivery. To understand how AI-driven healthcare technologies influence nurse-patient relationships, Buchanan, Howitt, Rita Wilson, Risling, and Bamford (2020) did a scoping review of the relevant literature. Preliminary results from screening the literature showed that social robots that utilize AI were being used more frequently in long-term care settings with elderly patients. This may influence the therapeutic relationship between patients and their nurses. The emergence of more advanced, AI-driven clinical predictive models using AI-driven technologies can positively impact patient care. Nurses are actively involved in the development of these AI-driven digital health technologies. Using technology in healthcare increases the responsibilities and risks for nurses. In this respect, the influence of AI on compassionate care is important. The limitations of this review were the incompleteness of the search as engineering and technology databases were not searched, the non-inclusion of peer review of the search engines, the use of percentage agreement for inter-rater agreement, which is inferior to Cohen's kappa method, and not assessing the quality of the papers, which may not be necessary for scoping reviews.

Trocin, Skogås, Langø, and Kiss (2022) presented the Operating Room of the Future (FOR), a research infrastructure and an integrated university clinic developed from a multidisciplinary collaboration

between St. Olav Hospital in Norway and the Norwegian University of Science and Technology (NTNU), and key initiatives related to AI technology. The main goal of these projects was to support medical professionals to combine their expertise with novel AI technology for improving their work performance. AI is a part of the digital transformation in healthcare, for which, DI is required. The authors discuss the various aspects on which the research infrastructure, FOR, can be used.

Rapid developments in DI, AI and intelligent algorithms have led to better ways of digital picture processing, and pattern recognition. In clinician- AI interactions, clinicians need to perform the roles of a client, designer and evaluator of AI tools in different clinical contexts (Zeng, Liang, & Chen, 2020).

Gunasekeran, Tseng, Tham, and Wong (2021) aimed to do a scoping review on the applications of artificial intelligence (AI), telehealth, and other relevant digital health solutions for public health responses in the healthcare operating environment during the COVID-19 pandemic. The authors also noted that the performance of digital health technology for operational applications for population surveillance and points of entry has not been adequately evaluated. These also found gaps and opportunities for further digital public health including further research on the applications of AI for public health stakeholders.

2.4 Fashion Industry

The need for using DI as a pre-requisite for AI integration in the fashion industry was stressed and discussed in detail by Kampakaki and Papahristou (2020). In addition to updating the skills of employees, the development of a digital environment (DI) is required to use AI effectively. DI and AI are likely to grow very fast in the coming years.

2.5 Oil and Gas Industry, Energy

According to Ball, Arbus, Odi, and Sneed (2017) over the next decade, AI will contribute to cost and operational efficiencies in the digitalised oil and gas production systems. New digital oilfields, using disruptive technologies, will create new value streams for exploration and production using automated decisions and reactions in real-time. This will tremendously improve operational efficiencies, connected infrastructure platforms, and better interaction between machines and humans. AI will be used to increase the precision of predictions. AI can help with predictive analytics, text analytics of drilling and machine learning in the completion of tasks.

Digitalization has become a critically important direction to move forward innovations in energy. To determine which digitalisation is more appropriate, Lyu and Liu (2021) analysed a near-universe of online job postings data collected between 2010 and 2019. Among the emerging digital technologies (AI, Big data, Internet of Things, Robotics, Blockchain technology, and Cloud computing), AI Intelligence is the most widely adopted in the energy sector. AI jobs fetch high wages and perks. AI also contributed the most to firm performance. Therefore, energy firms should intentionally increase the requirement for AI-trained employees by hiring new talents, with specialisation. Major energy firms can play a leading role in his respect.

2.6 SMEs

Aiming to explore the process of intelligent transformation of SMEs in Central China, Wang, Lu, Fan, Hu, and Wang (2022) interviewed 66 SMEs across 20 industries. SMEs in Central China are disadvantaged by a lack of resources and funds. Internal and external pressures are forcing these SMEs to intelligent transformation using DI and AI step-by-step.

2.7 HR Practices

The future of HR practices with AI and DI was discussed by Meister (2019). The stress will be on machine-human collaboration, rather than the replacement of humans by machines. This will help to improve the efficiency of the HR processes, benefitting the whole organisation.

2.8 Education

A survey of 98 public relations students and interviews with 20 PR practitioners were used by Cismaru, Gazzola, Ciochina, and Leovaridis (2018) to explore the difficulty of addressing constantly two categories of the public (the older traditional public, and the young public with a higher level of digital skills) and the educational gap of the curricula not addressing DI in an integrative manner. Four types of digital skills were explored: operational skills, information skills, strategic skills and the skills of digital fluency. Students possessed almost equally good levels of these skills. PR practitioners showed high adaptation levels to the digital environment, especially in the case of information and strategic skills. Relatively young (25-35 years old) PR practitioners showed a high level of y to deal with opportunities and threats of communication in online social networks and to address them differently to the public. Apart from the small sample size for the survey, other limitations were as follows. The first limitation appeared in the quantitative survey, in comparing the four types of skills. The fact that the third category of skills, strategic skill, has been coded as a set of actions, instead of being coded as a set of self-assessed abilities, created differences in measuring. They were solved by weighting the percentages at the recording of the composite variable (corresponding to the strategic skills category). A second limitation showed up when evaluating the sample of PR specialists who responded to the interview. The average age of this sample (n=20)

is quite low, 30 years, and the respondents are thus representing a young generation of PR specialists, with more openness and experience in social media communication. The results of the qualitative method were evaluated from this perspective. The third limitation was that the level of digital skills could not be compared between the sample of respondents and the sample of specialists, as a survey and interviews were used for the respective samples.

2.9 Intelligence Research

The role of AI and DI in intelligence research was discussed by Even and Siman-Tov (2020). Integrating artificial intelligence in research work may be beneficial in both their routine research activity and integration. The AI technologies may facilitate integrating the intelligence assessment of the situation and enable intelligence organizations to present scenarios to leaders for predicting the behaviour of human actors. This will help to determine any changes required high-level strategies course. DI needs to be adapted for communications between databases and machines. The challenges are the lack of high-quality language processing for both humans and machines.

2.10 Diplomatic Relations

According to Bjola (2020) Ministries of Foreign Affairs could deploy the TIID framework as a conceptual roadmap for designing, delivering and deploying AI solutions in diplomacy, that combines considerations about what the objective is (task improvement), how to accomplish it (innovation), with what resources (physical/digital integration) and in what institutional configuration (deployment). Thus, a physical-to-digital integration loop with AI can rationally help diplomatic decisions.

2.11 Dual divide

Yu (2020) pointed out the digital and algorithmic divide existing in the world due to varying capacities and capabilities of people in different countries with varying infrastructural; political, social, economic, cultural, educational, and career factors. Using a review of the literature, the author identified five attributes of this dual divide: awareness, access, affordability, availability, and adaptability. Three major problems due to the emerging and fast-expanding algorithmic divide identified were algorithmic deprivation, algorithmic discrimination, and algorithmic distortion. Seven non-exhaustive clusters of remedial actions (literacy, amelioration, ethics, transparency, accountability, competition and perspective) were proposed as the solution to the digital and algorithmic divide.

2.12 Digital Ethics

The use of Artificial Intelligence (AI) in Digital Technologies (DT) is spearheading deep socio-technical transformation. Governments and AI scholars have recognised key AI principles but do not know how to implement them. The ethical use of AI and DI is critically important. In a systematic review of 59 papers, Ashok, Madan, Joha, and Sivaraja (2022) identified 14 digital ethical implications of using AI in seven DT archetypes. The authors proposed a conceptual model with twelve propositions, in which, the impact of the 14 digital ethics implications is moderated by the seven DT archetypes and mediated by organisational impact. Out of the 14 implications, the cognitive domains of intelligibility, accountability, fairness, autonomy and the information domain of privacy have been discussed at length. The domains of governance and safety are also important.

3. DISCUSSION

The selected papers reflect research on DI and AI and their interface in a wide range of contexts. This means, both DI and AI can be used to obtain benefits for the entity using them. However, there are challenges in implementing them. The very first challenge is understanding these concepts. Determining the method of implementation is a big challenge. The factors and implications of using DI and AI need to be properly understood, to achieve the full potential of their benefits. Only two papers mentioned any theories used. Verganti, Vendraminelli, and Iansiti (2020) used design and innovation theory for explanations. Ågerfalk (2020) used social theory, institutional theory and agency theory to explain different aspects dealt with in the paper, as AI was considered an agency of DI.

Out of the 26 reviewed papers, major areas of research done were on business, healthcare and general aspects of using DI and AI. These three together accounted for over 60% (16 out of 26) of the reviewed papers. Only one paper each was seen on other topics, except the oil, gas and energy sector (two papers).

As shown in Fig 3, 31% of the papers (8 out of 26) were published in 2020, followed by 6 in 2021 (23%) and 4 (15%) each in 2017 and 2019. No paper earlier than 2017 was selected. This was due to an accident rather than deliberate.

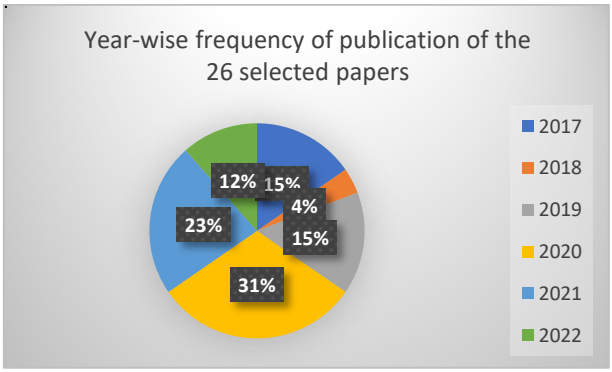

Figure 3. Year-wise frequency of the 26 selected papers

The frequencies of methods used in the 26 selected papers are presented in Fig 4.

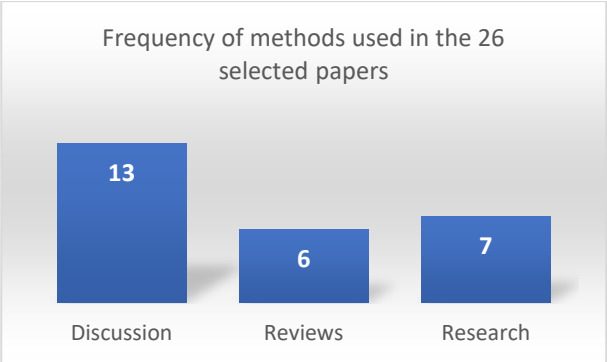

Figure 4. Frequencies of methods used in the 26 selected papers

Most papers (13 out of 26) were discussion papers. Only 7 papers were research papers, which included surveys, case studies and secondary data collection.

4. CONCLUSION

This review clearly shows that using AI as a pre-requisite of DI will confer many benefits to the organisation in any sector. Healthcare notably benefits from this integrative use of DI and AI.

However, to implement this, a proper understanding of both concepts is necessary. To help organisations, curricula of universities need to impart DI and AI skills and practical methods of their application to the students.

There is a fear of enhancing the digital divide when DI and AI are added to the already existing digital divide due to other causes.

Methods to enforce compliance with digital ethics by different types of organisations need to be developed internationally. International organisations can contribute to this effort.

Future research and limitations: There was no paper reporting on the impact of DI in the adoption of AI by any organisation. Hence, research needs to be started on this topic.

Only a few aspects across different sectors were covered by the currently available papers. Many more papers on more sectors and more aspects need to be published.

As was pointed out above, no paper was available on the actual impact of DI on AI, which was the review topic. So, the findings are interpretative rather than direct.

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