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Stylised-facts view of fourth industrial revolution technologies impacting digital learning and workplace environments: ChatGPT and critical reflections

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When the 21st century was ushered in, and in the period following its inception, there was a lot of hype about how 21st-century skills, especially the 4Cs (critical thinking, collaboration, communication, and creativity), were going to play a pivotal role for digital learning and workplace environments. Two decades later, these environments are still grappling with the specific changes brought about and the actual role played by these skills in their respective facets. Within these two decades, though, a new hype has emerged about how fourth industrial revolution (4IR) technologies are likely to affect and change the future of digital learning and workplace environments in ways never seen in previous industrial and digital revolutions. Amongst these technologies, artificial intelligence and automation are touted as some of the technologies that will change the future of digital learning and work. Against this background, this paper sets out to critically reflect on the prospects and challenges these two 4IR technologies have for digital learning and work as the 21st century is on the cusp of the third decade. It does so by analysing and discussing AI–/machine–human fused stylised facts based on ChatGPT-generated responses and on a human distillation and reworking of those responses.

KEYWORDS

fourth industrial revolution, stylised facts, digital learning, workplace, artificial intelligence, automation, ChatGPT, critical reflections

1. Introduction

At the cusp of the twenty-first (21st) century, there was much talk about 21st-centruty skills and how they were going to change and impact the future of learning and of work. In certain instances, this talk developed into calls or exhortations that became almost like mantras or hypes. Some of the classic examples are: 21st century skills (Morgan, 2007; Partnership for 21st Century Skills, 2008; Dede, 2009; Joynes et al., 2019; Reaves, 2019); 21st century skills and serious games (Spires and Annetta, 2008); 21st century learners (Lambert, 2002); 21st century literacies [National Council of Teachers of English (NCTE, 2007, 2008)]; 21st century learning [Centre for Educational Research and Innovation (CERI, 2008; Chaka, 2010a, 2019)]; 21st century standards and curriculum (Alismail and McGuire, 2015); pedagogies for the 21st century (Whitby, 2007); writing in the 21st century (Yancey, 2009); 21st century skills for 21st century jobs (Stuart and Dahm, 1999); 21st century workplace (Pennsylvania Department of

Education, 2008); and skills for a changing world (Care et al., 2017). Needless to say that most of these examples are parts of titles of articles on 21st century skills.

The much-vaunted 21st-century skills talk was engendered by the new century itself and by the new digital technologies that had emerged, especially Internet-based technologies. Whenever a new era or period—both temporal and technological—is ushered in, there is often a hype about what will and what will not happen in that era. In fact, in the period leading to the year 2000—the launch year for the 21st century—the new Y2K hype suddenly emerged. The year 2000 (Y2K) was a shorthand or a codename for the bug that was supposed to crash the computer and Internet infrastructure and ecosystem at the stroke of ushering in the year 2000. The crash was to have resulted in an unimaginable chaos throughout the computer-Internet ecosystem, with ripple effects to all technological ecosystems dependent on the computer-Internet ecosystem (see Uenuma, 2019). It is no secret that the year 2000 came and went, and that it is now 2022, yet, nothing ever happened. Concerning 21st-century skills, their hype that they would change how learning and work are conducted, was fuelled by the World Wide Web (WWW) that had been invented in 1989 and by subsequent Web 2.0 technologies that came into existence in the first decade of 2000 (see Chaka, 2009, 2010b,c, 2011). Fortuitously, some scholars prepared enough attitudinal change and take-off through the ideas they published and disseminated during this period. Two such scholars were Prensky (2001) through his polar notions of *digital natives* and *digital immigrants*, and Dede (2005) through his tantalising ideas of *neo-millennials* and *neo-millennial learning styles* (cf. Evans and Robertson, 2020). These developments, together with both the new century and the attendant seductive ideas propagated then, were seen as the much-needed launching pad for 21st-century skills. However, it is now almost 22 years into this century, and the jury is still out as to whether these skills have radically changed learning and the workplace.

In a scenario that parallels that of 21st-century skills, fourth industrial revolution (4IR) technologies seem to be similarly occupying the centre stage at the moment. Again, in a similar manner, they are seen as heralding wide-ranging changes for both learning and work in this century on several fronts and in different sectors, particularly, of work. This is especially the case with artificial intelligence (AI) and automation. They, too, have, under the umbrella moniker, 4IR, or under its other 4.0 iterations, or just individually, generated a lot of tag lines, a few examples of which include: '21st-century skills and the fourth industrial revolution' (Reaves, 2019); 'how will the fourth industrial revolution impact the future of work' (Change Recruitment, 2017); '21st century fourth industrial revolution workplace' (Govender and Adegbite, 2022); 'preparing tomorrow's workforce for the fourth industrial revolution' (Deloitte, 2018; also see Oosthuizen, 2022); 'the future of education according to the fourth industrial revolution' (Elayyan, 2021; also see Butler-Adam, 2018); 'sustainable development and education in the fourth industrial revolution (4IR)' (Ally and Wark, 2020); and 'millennials, this is how artificial intelligence will impact your job for better and worse' (Marlin, 2018). All of these examples are parts of titles of articles on either 4IR and learning/education or 4IR/Industry 4.0 and work/workplace/employment/jobs. The argument here is that these technologies, individually and severally, will transform and disrupt the future of learning and work. Some of the tag lines associated with these technologies, as evident from the few examples provided above, are conspicuous by their seductiveness and by their messaging intent in promoting these technologies. As is the case with 21st-century skills, which in some instances get twinned with 4IR technologies, various articles and varied promotional ideas tend to serve as the much-needed launching pad for these 4IR technologies.

In addition to numerous articles and some books on the possible impact of 4IR on the future of learning and work, there are literature, systematic reviews, and surveys that have been published on such a likely impact. Some of these reviews include:

Balliester and Elsheikhi (2018), Belpaeme et al. (2018), Wichmann et al. (2019), Zawacki-Richter et al. (2019), Butt et al. (2020), Yusuf et al. (2020), Chaka (2021, 2022a, 2023), Lepasepp and Hurst (2021), Mitchell et al. (2021), Da Silva et al. (2022), Khadragy (2022), Moldoveanu (2022), Nasreen et al. (2022), Oosthuizen (2022), and Filippi et al. (2023). Against this backdrop, this paper intends to engage with and reflect on how two 4IR technologies, AI automation, are likely to affect and change the future of digital learning and workplace environments. It does so from a critical perspective. In particular, it employs a stylised-facts view of the prospects and challenges of these 4IR technologies in relation to digital learning and workplace environments.

2. Stylised-facts framework and ChatGPT

This paper employs stylised facts as its conceptual framework. Having originated in and commonly used in economics where they have varied applications (for example, see Mendritzki, 2014; Abada and Khalifa, 2015; Hirschman, 2016), stylised facts have been used in other disciplines such as management (see Helfat, 2007) and social sciences, especially sociology (see Hirschman, 2016) as a conceptual tool. They have also been employed in technology (see Pianta, 2018, 2020). Kaldor (1961) is credited with having coined the term, *stylised facts*. Even though stylised facts are often deemed to be associated with conceptual vagueness and definitional imprecision, some scholars have attempted to define and unpack them (see, in particular, Mendritzki, 2014; Abada and Khalifa, 2015; Hirschman, 2016). The aim of this paper is not to do what these scholars and others have already done, but mainly to briefly synergise their definitional views of stylised facts in order to frame them as a theoretical underpinning for exploring and interrogating some of the prospects offered by and some of the challenges posed by the 4IR technologies cited above concerning digital learning and workplace environments.

Stylised facts are, according to Hirschman (2016) empirical regularities that need to be theoretically and causally explained, and which can assume positive and normative claims. As positive claims, they are about what exists in the world; as normative claims, they indicate what warrants scholarly gaze. Two statements exemplifying stylised facts are: *married couples rarely fight each other* and *higher debt-to-GDP ratios lead to lower GDP growth in most countries*. Mostly, stylised facts are situated between theory and description, and between minimal and maximal interpretation. One important feature of a stylised view of facts is focusing more on broad tendencies than on the finer details of these tendencies (also see Kaldor, 1961).

Moreover, there are two contrasting views of stylised facts: a strict view and a fictionalist view. The former view insists that stylised facts are strictly based on explananda or statistical evidence, whilst the

latter view maintains that stylised facts have nothing to do with concrete evidence. In this latter sense, stylised facts contrast with facts proper (Mendritzki, 2014). Furthermore, stylised facts differ from bare facts (BFs) in that the latter constitute commonly accepted knowledge amongst specialists. In this way, BFs can be inferred with a high sense of validity from reliable data, and through a theoretically sustained explanation. Importantly, stylised facts do not require BFs as their prerequisites for them to exist. Neither can they be validly inferred from reliable data: they are data-constrained (Abada and Khalifa, 2015). There is another sense that this paper wants to convey about stylised facts, which is not embodied in the original conceptualisation of stylised facts: that they are like slogans (in a political sense) or like hyped statements (in a marketing or advertising sense).

Against this background, some of the stylised facts related to technology are 'technology saves human labour,' 'the impact of technology is different across occupations and skills,' and 'technology is an engine of inequality' (Pianta, 2018, 2020). Concerning this paper, the following stylised facts are the points of analysis and discussion:

- AI and automation, as part of 4IR technologies, would lead to the automation of certain tasks and jobs, resulting in changes in the skills and knowledge that workers would need to possess for them to remain competitive in the job market.
- AI and automation, as instances of 4IR or Industry 4.0 technologies, will offer greater access to remote learning and will provide more access to remote working, enabling workplace collaboration.

These two stylised facts are drawn and distilled from the different text types generated by ChatGPT after I queried it with prompts that I wanted it to respond to (see Appendix A). The distillation and reworking was done in order to fuse AI-generated responses with a human reworking of those responses. In this case, ChatGPT served as a data collection tool and its generated responses served as data sets. The querying of prompts to ChatGPT happened between 23 December 2022 and 03 January 2023. GPT in ChatGPT stands for Generative Pre-trained Transformer. In short, ChatGPT is an artificial intelligence (AI) assistant owned by OpenAI (Williamson et al., 2023), which was released in November 2022 after its predecessor, GPT-3, whose release was in 2020. It is an AI-powered large language model trained to produce text, as per bespoke query, by crawling tons of words available from training datasets existing in the Internet and parsing them together in response to a specific query (see Stokel-Walker, 2022). Based on the AI technology that drives it, it is able to create natural, human-like conversations with its users. Currently available to the public, at the time of writing this paper ChatGPT had garnered more than a million users in a few days after its release. It was also being touted as a game-changing app that every teacher needed to take note of Harris (2022). Hern (2022) refers to it as the latest chatbot to have evolved from text-generating AIs that belong to the GPT family of bots (also see Heilweil, 2022).

When I queried ChatGPT about what it is, using the question, *ChatGPT, what are you, and how different are you from the other chatbots*?, and regenerating another response, this is the sample of what it generated in the first and second instances, respectively: 'I'm Assistant, a large language model trained by OpenAI. I'm not a chatbot in the traditional sense, as I don't have a pre-defined set of responses to specific inputs' and 'I am Assistant, a large language model trained by OpenAI. I am not a chatbot, but rather a programme that uses machine learning to generate human-like text based on the input I receive' (ChatGPT, 2023). Not only does ChatGPT generate text, it is also able to summarise text, define terms, remix pieces of text, create poems, offer examples, provide tips or suggestions for solving coding problem, and do other bespoke tasks it is requested to do (see Cutcliffe, 2022; Harris, 2022; Hern, 2022; Solé, 2023). Heilweil (2022) aptly sums up the further capabilities of ChatGPT as an AI model when she highlights that it can 'make jokes, write TV episodes, compose music, and even debug computer code' (par. 3).

With all the claim that it is AI-powered, that it uses machine learning, and that it generates natural, human-like responses—the claim its generated responses confirm—I decided to employ ChatGPT as a use case tool (case study) for both AI and automation as instances of 4IR technologies in relation to digital learning and workplace. Again, based on this claim and as pointed out earlier, I employed it to extract and repurpose the stylised facts for this paper from it. My using of ChatGPT as an instance of a 4IR AI and automation does not mean that the system is flawless, uncheatable, and without limitations, and that it does not, at times, raise eyebrows or generate some controversies. One glaring concern is that ChatGPT generates datasets or chunks of information from the Internet without acknowledging them or without permission from authors. Due to this, it is seen in some quarters as promoting *copyright laundering*, a practice of deriving information from existing sources without breaching copyright (Hern, 2022). This is complicated by the fact that plagiarism-detection software tools such as TurnItIn and iThenticate are, for now, unable to detect plagiarism in ChatGPT-generated responses (Cutcliffe, 2022; Heilweil, 2022). At times, ChatGPT gets tripped by riddles or makes up stuff (Heilweil, 2022). It also generated incorrect or unhelpful responses when prompted to provide advice on beating a car-stealing mission for a fictional VR game, *Car World*. In addition, even though the system refuses to answer queries related to crime such as stealing a car (Hern, 2022), it is, nonetheless, as Heilweil (2022) points out, not entirely impossible to trick it into sharing advice about nefarious or evil activities. Moreover, Heilweil (2022) notes that an earlier version of GPT would, at times, generate offensive or biassed Islamophobic snippets. A noteworthy point is that at the beginning of January 2023, OpenAI, the parent company of ChatGPT, indicated that it was piloting a premium version to be called ChatGPT Professional with a view to charging or monetising the use of ChatGPT (Wiggers, 2023).

No sooner had ChatGPT been released than an app was created a few weeks later to detect whether a text is AI- or human-generated. Called GPTZero, the app was created by a senior computer science student at Princeton University. The app uses two indicators, perplexity and burstiness, to instantaneously determine if a text is AI- or human-generated. The former measures text complexity: if the text perplexes the app, the app identifies it as complex, and thus as human-generated. The converse is true: if the text is less complex, and does not perplex the app, it is judged as AI-generated. The latter, burstiness, is about sentence or text variation. Humans vary their sentences, whilst AI-driven machines such as ChatGPT do not (Bowman, 2023; Meghmala, 2023). GPTZero has a higher degree of text detection accuracy, and not a 100% text detection accuracy. In an instance in which it was trialled by Tangermann (2023), it accurately detected seven ChatGPT-generated pieces of text out of eight text pieces. In addition, it identified six pieces of human-written text out of eight.

When I trialled it, it managed to recognise all the three ChatGPT-generated pieces of text I inputted into it. However, when I inputted eleven human-generated pieces of text (seven journal paper abstracts and four online extracts), it accurately identified nine inputs, but failed to give its verdict for two abstracts, for which it needed more data to be inputted for it to be able to determine their human or AI generation.

3. Stylised facts

3.1. AI and automation, as part of 4IR technologies, would lead to the automation of certain tasks and jobs, resulting in changes in the skills and knowledge that workers would need to possess for them to remain competitive in the job market

This can be seen to apply to workers in both learning and workplace environments. The framing of this stylised fact in probabilistic terms, its use of unspecified and unnamed workplace tasks and jobs, and its unspecified skills and knowledge underline its uncertainty. However, its uncertainty finds resonance in statements such as 'Robots and AI taking over jobs: what to know about the future of jobs,' 'Artificial intelligence is poised to eliminate millions of current jobs …' (Thomas, 2022), and 'Professors, programmers and journalists could all be out of a job in just a few years, after the latest chatbot from … OpenAI foundation stunned onlookers with its writing ability, proficiency at complex tasks, and ease of use' (Hern, 2022). This is particularly so if such statements are taken uncritically. Of course, certain tasks and jobs, as asserted in the stylised fact, might be automated as a result of 4IR related AI and automation technologies. But the idea of certain tasks and jobs being automated is not an exclusive preserve of stylised facts. It is also expressed by Internet search engine algorithms. For instance, just typing the phrase, 'Will machines …,' into Google, provides some of the following varied but tailored prompts: '… replace humans'; '… take over jobs'; '… replace doctors'; '… replace humans in the future of work'; and '… take my job' (also see The Economist, 2018). Doing so into Bing offers, amongst the other prompts, the following: '… replace humans'; '… take our jobs'; '… replace human workers'; and '… replace humans in the future.'

In addition, such ideas have, in the past, been expressed in varying degrees in other contexts by scholars like Frey and Osborne (2013) and Nedelkoska and Quintini (2018), and lately by Badet (2021), Acemoglu and Restrepo (2022), Li (2022), Nasreen et al. (2022), Masriadi et al. (2023), and Williamson et al. (2023). As early as 2013, in a paper titled, 'The future of employment: How susceptible are jobs to computerisation?,' Frey and Osborne (2013) asserted that out of 702 occupations they had analysed in the United States (U.S.), they estimated that about 47% of overall U.S. employment would be at risk of computerisation or automatability within two decades (*cf.* Badet, 2021). They identified jobs such as transportation and material moving, production, construction and extraction, office and administrative support, sales, and service as falling within the high-probability band of computerisation. Conversely, they singled out healthcare practitioners and technical service, education, legal service, community service, arts and media, computer, engineering and science, and management, business and finance as being in the low-probability band of computerisation. That is, they estimated that only 33% of these jobs would be susceptible to computerisation within these two decades. In terms of skills—what they refer to as variables according to their model—fine arts, originality, negotiation, persuasion, social perceptiveness, and assisting and caring for others, all of which they regarded as social intelligence skills, were less likely susceptible to computerisation (*cf.* Masriadi et al., 2023). However, they argued that manual dexterity, finger dexterity, and cramped work space lent themselves to automisation (Frey and Osborne, 2013). In contrast, Masriadi et al. (2023) argue that several human-intensive jobs have started being replaced by machines/robots in the health, banking, and telecommunications sectors. However, they caution that not all types of work and activities in these sectors can be replaced by AI and automation, particularly jobs and tasks that require human intuitive and empathic intelligence, which machines/robots do not currently possess.

In another instance, a paper by Nedelkoska and Quintini (2018) that evaluated the automatability of job tasks within given occupations in 32 countries belonging to the Organisation of Economic and Cooperation Development (OECD), rated food preparation assistants at the top of the automatability probability scale, followed by cleaners and helpers, labourers in mining, construction, manufacturing and transport, and assemblers. It ranked teaching professionals at the bottom of the scale, followed by production and specialised services managers, and chief executives, senior officials and legislators. In terms of industries, the paper placed agriculture and hunting at the top of the automatability probability scale, with education at the tail end of this scale, and followed by head offices and management consultancy. This automatability of job tasks contrast with those Masriadi et al. (2023) contend that have already begun being automated.

When I inputted the prompt, 'What tasks and jobs will be automated by AI and automation?,' into ChatGPT, it listed the following jobs: data entry and processing; customer service; manufacturing; driving; agriculture; and healthcare (see Supplementary Table 1). Of course, it regarded them as a small sample of many jobs and tasks being currently automated by AI and by other types of automation. Whilst the order of occupations or industries listed as susceptible for AI and automation by ChatGPT is different from that of the jobs and industries identified by Frey and Osborne (2013) and Nedelkoska and Quintini (2018), five of its industries (barring data entry and processing, and healthcare) are the same as those mentioned by these scholars. Healthcare coincides with one of the sectors that Masriadi et al. (2023) identify as being already under automation. However, there are manifest differences between the manner in which ChatGPT has characterised its automatable industries and the way in which Frey and Osborne (2013) and Nedelkoska and Quintini (2018) have characterised theirs. ChatGPT offers a brief generic preamble of its only seven candidate jobs for automation before it lists such jobs. Each listed job is accompanied by a short explanation with example job tasks. Two listed jobs have one example job task, each. Manufacturing is regarded as already under automation through both industrial robots and related forms of automation in areas such as painting, welding, and assembling. Two jobs (in the sense used here), healthcare and retail, are seen as having AI being used in some of their areas. This contention about healthcare resonates with that made by Masriadi et al. (2023). If this is the case, healthcare and retail together with manufacturing ought to have been

identified as candidate jobs that will be automated by AI and automation according to the prompt queried to ChatGPT because automation is already happening in them. Additionally, some automation is already taking place in jobs like data entry and processing and driving, but the ChatGPT still says, 'AI can be used to automate and process …' and 'Self-driving vehicles are being developed and tested …' for each of them, respectively. This highlights its machine-generated responses, which are incapable of differentiating between the forms of automation that have already taken place in these two jobs and those in which AI and automation are still being developed and trialled. This point becomes even much glaring when factoring in Masriadi et al.'s (2023) argument about banking and telecommunications. Moreover, it is inconceivable that only seven jobs can be candidates for automation in this day and age. This is a far cry from the 702 occupations (in the U.S.) and from the 38 occupations (in 32 OECD countries) that Frey and Osborne (2013) and Nedelkoska and Quintini (2018), respectively, refer to in their studies. It is also unimaginable that ChatGPT cannot see banking and telecommunications as already experiencing AI and automation, or at least as possible candidates for AI and automation.

Furthermore, ChatGPT's listing of healthcare as a candidate job for automation contrasts with Frey and Osborne's (2013) characterisation of this sector, which, together with the other jobs such as education mentioned earlier, was ranked in the low-probability band of computerisation by Frey and Osborne (2013). Of course, it must be conceded that ChatGPT generated its predictions in 2023, even though the cut-off date for its training data is September 2021, whilst Frey and Osborne (2013) made their predictions ten years ago. Of particular interest is that ChatGPT does not list education, or digital learning or some aspects of it in particular, as a candidate job for automation. As highlighted earlier, Frey and Osborne (2013) accorded education a low-computerisation probability, with Nedelkoska and Quintini (2018) also placing it at the tail end of the automatability probability scale. Whilst the time differences between when the two studies (ten years and five years, correspondingly) were conducted and the use of ChatGPT in 2023 cannot be ignored, it is implausible why ChatGPT does not regard education, especially digital learning, as a candidate sector for automisation. This is more so, since it already automates or produces AI-generated responses that cover a whole spectrum of educational matters, notwithstanding the drawbacks of some of those responses as pointed out earlier. Whilst Masriadi et al. (2023) similarly do not mention education's susceptibility to AI and automation, Williamson et al. (2023) argues that 'corporate infrastructuring' (p. 3) in the form of private platforms owned by private IT companies, which both schools and universities embrace, has already introduced a form of automation in these two sectors of education. Why ChatGPT is not able to pick this up is a moot point as the platformisation of education (see Williamson et al., 2023) predates September 2021, the cut-off date for ChatGPT's training data.

The same implausibility applies to ChatGPT not listing the workplace and the financial sector for automation as well (see Zervoudi, 2020; White House, 2022; Masriadi et al., 2023). Not only does the financial sector lend itself well to automation in its different fintech areas, but it is one of the growth industries for different forms of automation. This pedestrian shortcoming underscores the fact that ChatGPT is an AI tool and that it cannot, in a case such as this, think like a human being. It cannot see itself as automating some aspects of both education and workplace by generating responses it does. This is a point that dovetails with McKinsey Global Institute's (2018) view that two of the major limitations of AI and automation are the unavailability of unlimited training data and the inability of machine-learning algorithms to generalise across diverse use cases (also see Chaka, 2022b,d, 2023). Two noteworthy points made by McKinsey Global Institute (2018)—with their five-year time differential—are that almost half of the activities (not necessarily jobs) done by workers could be automated and that machines would be able to perform more of the tasks done by humans. Even though these were predictions made 5 years ago, ChatGPT does not commit itself to making such probable predictions 5 years later.

Whereas Frey and Osborne (2013) and Nedelkoska and Quintini (2018) offered possible time durations within which they estimated automatability would occur in certain occupations, ChatGPT is non-committal about such estimated time frames. In fact, estimating time frames within which the automation of jobs would take place has been one of the stylised facts characterising the *discourse* about AI and automation. This is especially the case with estimations that are broader (in tendencies) than those that are specific (in details) as Kaldor (1961) once suggested for stylised facts. Some of the classic examples related to two of the sources cited in this paper are: out of 702 occupations, about 47% of overall U.S. employment would be at risk of computerisation or automatability *within two decades* (Frey and Osborne, 2013); and 'about 14% of jobs in OECD countries participating in PIAAC are highly automatable (i.e., probability of automation of over 70%)' (Nedelkoska and Quintini, 2018, p. 7). Although ChatGPT does not have such estimations, but its use of phrases like 'many tasks and jobs that are being automated' and 'more and more tasks and jobs will be automated in the future' (see Appendix A) display elements of estimations that have broader tendencies as argued by Kaldor (1961).

There are five stages of human job replacement by AI that Masriadi et al. (2023) identify. The first stage is about AI replacing mechanical, repetitive jobs and the second stage involves AI replacing jobs requiring analytical skills. The third stage entails the simultaneous replacement of jobs dependent on mechanical, analytical, and intuitive skills by AI. The fourth stage is when AI replaces job skills related to the first three stages together with jobs requiring empathetic skills. The fifth stage is when AI replaces the job skills embedded in the first four stages by possessing and replicating all these job skill sets by itself. Whilst these job replacement stages attributed to AI look simplistic, and there is no evidence that there are AI tools that are currently operating as the fourth and fifth stages, ChatGPT could not even mention a stage at which AI and automation could replace jobs done by humans. Nor could it identify job skill sets that AI and automation could replace.

In terms of the resultant skills and knowledge that workers would need to possess for them to remain competitive in the job market as framed in the stylised fact under discussion, ChatGPT did not have anything to say in this regard. Instead, it only mentioned tasks associated with its listed candidate jobs, which are not new tasks.

3.2. AI and automation, as instances of 4IR or industry 4.0 technologies, will offer greater access to remote learning and will provide more access to remote working, enabling workplace collaboration

Unlike the previous stylised fact, the current stylised fact is framed in futuristic terms, with a higher degree of certainty. It was distilled

and reworked from prompts given to or from questions posed to ChatGPT, one of which was, 'What are the prospects and challenges the 4IR technologies have for digital learning and work?' (see Supplementary Table 2). In response, ChatGPT was able to say that 'Fourth Industrial Revolution (4IR) technologies' are also regarded as 'Industry 4.0 technologies' (see Appendix A). Then, it mentioned such examples of 4IR technologies as AI, the Internet of Things (IoT), big data and analytics, and cloud computing. From there, it generated two main prospects that 4IR technologies have for digital learning. Firstly, it mentioned their potential to personalise and enhance the learning experience. Here it singled out AI-powered learning systems as having the capability to adapt to learners' individual needs and preferences through personalised content and feedback. Secondly, it indicated that 4IR technologies can offer new forms of interactive and immersive learning to facilitate engaging and interactive learning experiences for learners through virtual and augmented reality.

For work, it also generated two prospects. Firstly, it said that 4IR technologies have the potential to transform the way work is done. It exemplified this by mentioning that AI and automation can assist in streamlining processes and improving efficiency, whilst IoT can facilitate remote monitoring and control of work processes. Secondly, it pointed out that 4IR technologies can enable remote work, thereby allowing for more flexible and agile work models. Pertaining to challenges, it identified generic ones for both digital learning and work. For example, it singled out three main ones. The first one is the need for new skills and training (upskilling) for individuals to remain competitive. This is followed by job displacement as it argues that AI systems will automate certain tasks. The third challenge is prevalent inequalities and disparities that it says will be aggravated by the adoption of 4IR technologies. It advices that businesses, governments, and related stakeholders address such inequities in order to ensure shared benefits of 4IR technologies.

The two digital learning prospects, personalised learning and immersive learning offered by ChatGPT are not the only ones that AI and automation can offer. Others include adaptive and context-aware learning, intelligent tutoring, automated student responses, automated grading, and personalised assessments. However, all of these AI and automation applications, including the ones mentioned by ChatGPT are not new anymore. They have been in use for a whilst now. Intelligent tutoring chatbots and automated grading are some of the classic examples, in this regard (Luckin et al., 2016; Chaka, 2023). Even immersive learning is already being applied in certain learning contexts (see Peixoto et al., 2021). Remote learning is another prospect offered by AI and automation, which ChatGPT could not figure out in its generated responses. Whilst this mode of learning is not necessarily new as it has characterised distance learning in one way or another, 4IR technologies such as online collaborative communications tools, especially in the form of MS Teams and Zoom, tend to offer a value-added affordance to remote learning. They do so through real-time learning or communication provided by video conferencing and instant chatting (see Hewson and Chung, 2021; Chaka et al., 2022). These technologies are some of the 4IR technologies that some universities pivoted to and adopted during the COVID-19 pandemic (Almarzooq et al., 2020; Chaka, 2021, 2022c), even though Chaka (2022c) refers to them as 'low-tech versions of the 4IR technologies' (p. 19).

Concerning work prospects, ChatGPT only mentioned that IoT can allow work processes to be done remotely. But, it did not spell out which work processes these are. Likewise, it generically referred to the fact that 4IR technologies can enable remote work and allow flexible and agile work models without identifying which technologies these are and without specifying the flexible and agile work models in question. Even the five examples of 4IR technologies cited by ChatGPT, in this case, are the only ones it mentioned as falling under the 4IR banner. There are, nevertheless, other examples of 4IR technologies than the ones it mentioned (see Keser and Semerci, 2019; Chaka, 2020, 2021; Illori and Ajagunna, 2020; Elayyan, 2021; Lepasepp and Hurst, 2021; Alsoliman, 2022; Li, 2022; Mury et al., 2022; Chaka, 2023; Kibe et al., 2023). To this end, Change Recruitment (2017) argues that AI, automation, cloud technology, high-speed mobile Internet, and big data analytics are five key technological developments driving 4IR. However, it singles out AI and automation as the two 4IR technologies likely to significantly impact global workforce and, by analogy, digital learning. It also contends that, ultimately, it is smart devices (associated with both IoT and AI), which might possess sufficient information to make autonomous decisions and control critical business processes such as supply chains without any human intervention, especially in developed nations. Nonetheless, it should be noted that these workplace predictions have an almost five-year lapse. So, five years later, there is not much indication that this is happening. Or, if it does, it does so at a snail's pace contrary to the hype associated with such predictions.

In fact, if the COVID-19 pandemic can be used as a yardstick, no workplace, in both developed and under-developed countries, was spared a lockdown despite the presence of smart devices (IoT), AI, and automation. Indeed the word, *lockdown*, became one of the major mantras and one of the rallying points during the height of the COVID-19 pandemic in different nations in varying degrees. When tele-working and tele-learning took place, it was only after the fact, or as an afterthought as the pandemic had managed to upend humanity for a whilst (Catană et al., 2021; Chaka, 2022b). As is the case with digital learning, ChatGPT did not cite online collaborative communications tools as part of remote work in an AI-driven and automated workplace ecosystem. This highlights its banal nature as an AI-powered generative tool.

With reference to challenges, training employees for new skills or upskilling employees is not a phenomenon unique to the advent of AI and automation. Companies or employees have been and will continue training their employees to prepare them for any new or any changing demands in their workplaces. This is a point that Joynes et al. (2019) emphasise in relation to different education sectors and pertaining to different types of workplace. Job competiveness will always be there with or without the presence of AI and automation. ChatGPT also identified job displacement owing to certain job tasks being automated. Additionally, it did not say which jobs or which job tasks may be displaced, or which new ones might be created. Elsewhere, Change Recruitment (2017) asserts that switchboard operators have been rendered obsolete by mobile technologies. But it also argues that new job titles such as app developers, data scientists, and social media marketers have since emerged. In a different but related context, McKinsey Global Institute (2018) predicted that certain occupations would cease to exist by 2030. In fact, it put this bluntly by saying that about 400 million works, or 15% of the global workplace, could be displaced between 2016 and 2030 due to automation. However, it foresaw machines as playing a complementary role to humans in the workplace. A moot point here is whether this is materialising at the halfway point in 2023. But I hazard to say this is not yet the case. Not

even during the height of the COVID-19 pandemic was this the case as many global workplaces temporarily closed down. Actually, to defy the advent and zeitgeist of 4IR, particularly that of AI and automation, some of the big tech companies are threatening their employees with dismissals if they do not *go back to the office*. Not only that, post-pandemic, schools and universities have now reverted to in-person, bricks-and-mortar classrooms to resume the *old normal* in the era of 4IR.

The last challenge is the inequalities and disparities that will be exacerbated by the adoption of 4IR technologies. Even though ChatGPT does not put it in that way, these inequalities and disparities relate mainly to developed countries and under-developed countries. Yes, this a given: it is a stylised fact within stylised facts. Without belabouring this given fact, inequalities and disparities between these two sets of countries (for a lack of a better word), not only technology- or 4IR-driven ones, but in many spheres of life, have been there since the first industrial revolution. I venture to say even prior to industrial revolutions. Whilst these inequities and disparities are consequential and cannot be ignored, they are, nonetheless, not the function of the 4IR alone, or of the technologies associated with it alone. However, the impact that automation technologies have on workplace-related inequities cannot be ignored nor can they be dismissed. For instance, the study of Acemoglu and Restrepo (2022) demonstrates how, in the U.S. during the last four decades, between 50% and 70% of low-skill tasks, especially routine tasks, have been lost to automation technologies through task displacement, resulting in worker displacement and wage inequality in low-education demographic groups. Examples of automation technologies the study cites includes: bespoke software that automates different clerical and back-office tasks; and industrial robots or numerical control machinery that carries out blue-collar worker tasks. Looking at the points highlighted by this study, it becomes clear that inequalities and disparities are many and varied, and that they are not simply confined to contrasting sets of countries—rich, developed countries vs. poor, underdeveloped countries. In fact, some of these inequalities and disparities have to do with digital colonialism (Couldry and Mejias, 2019; Zembylas, 2021; Chaka, 2022d) and technological colonialism, both of which are beyond the scope of this paper.

4. Conclusion, limitations, and recommendations

This paper has attempted to offer a stylised-facts view of 4IR technologies, particularly, that of AI and automation. Whilst the arguments about whether AI is a technology or a field of study, and those related to whether automation is a process or a technology will always persist, this paper has taken a view that regards these two technologies as examples of 4IR technologies. In offering its stylised facts of AI and automation as explained earlier and as the basis of its analysis and discussion, the paper distilled and reworked these stylised facts from some of the responses generated by ChatGPT based on prompts that it was given. The distillation was human-driven. Therefore, the stylised facts used in the paper are a fusion of AI-generated automated responses and human-generated responses. A few years ago, this kind of dual (machine-human-interfaced) distillation and reworking would not have been feasible had an AI tool such as ChatGPT not been created. Within two months of its launch, there is no doubt that ChatGPT has proved to be a disruptive and game-changing AI technology that nestles itself well within the 4IR ecosystem. It is an AI utility tool that generates responses across disciplinary boundaries at a time when most human academics are locked within their disciplinary specialisation confines. In a way, it challenges disciplinary specialisms and lends itself well as an online transdisciplinary wealth of information, notwithstanding some of its shortcomings and some of its deficiencies as outlined earlier.

The rapidity with which ChatGPT generates responses should be a concern to a human brain that tends to generate and package ideas at a slow pace, sometimes with no guarantee that those ideas are correct or relevant. Now, for both learning and the workplace, is ChatGPT a harbinger of the death of an academic (human) Professor or the death of HR or of a human CEO? Lyotard (1984) asserted that computerisation would lead to the death of the Professor at the turn of the 20th century (also see Chaka and Mashige, 2016). Four decades later, this has not happened. So, the advent of 4IR, and especially that of AI and automation in the form of ChatGPT, may not necessarily herald the end of both the human Professor and the human CEO and their replacement with their AI counterparts. Rather, what it might herald is the different ways in which individuals occupying these two positions need to carry out some of their routine tasks given that they now have a 24-h, automated, all-knowing competitor in their midst.

As has been highlighted at the different points of this paper, some of the responses generated by ChatGPT had shortcomings as it could not detect some of the crucial aspects related to what it was prompted to respond to (see Appendix A). This underscores the fact that it is an AI tool that responds according to the data available to it, and that it is not a human being with a human brain. Hence, there was a need to bring in a human element to its generated responses as has been explained under the two stylised facts discussed above. Regarding the two stylised facts themselves, it became clear that they often operate as mantras or as hyped statements as has been the case with 21st-century skills. This means that they always have to be judged against and juxtaposed with existing literature with a view to testing their validity or their probability. Moreover, they need to be critiqued and not to be allowed to be passed off as statements of facts. For example, as argued earlier, some predictions about AI and automation are made as part of stylised facts, but time elapses without tangible evidence that these predictions have materialised.

Finally, the paper focused on only two stylised facts, which it discussed at length. Of course, it could have focused on more had space been available. Future research might need to focus on more styled facts. The version of ChatGPT that the paper used was the one released for public trialling in November 2022. It is expected that it would have some shortcomings. So, as a premium version of ChatGPT—ChatGPT Professional—is due to be released, future research could consider using it in lieu of a trial version.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1150499/full#supplementary-material

References

Abada, L. A., and Khalifa, K. (2015). What are stylized facts? *J. Econ. Method.* 22, 143–156. doi: 10.1080/1350178X.2015.1024878

Acemoglu, D., and Restrepo, P. (2022). Tasks, automation, and the rise in U.S. wage inequality. *Econometrica* 90, 1973–2016. doi: 10.3982/ECTA19815

Alismail, H. A., and McGuire, P. (2015). 21st century standards and curriculum: current research and practice. *J. Educ. Pract.* 6, 150–154.

Ally, M., and Wark, N. (2020). Sustainable Development and Education in the Fourth Industrial Revolution (4IR). Available at: http://oasis.col.org/handle/11599/3698

Almarzooq, Z. I., Lopes, M., and Kochar, A. (2020). Virtual learning during the COVID-19 pandemic: A disruptive technology in graduate medical education. *J. Am. Coll. Cardiol.* 75, 2635–2638. doi: 10.1016/j.jacc.2020.04.015

Alsoliman, B. S. H. (2022). Virtual robotics in education: The experience of eighth grade students in STEM. *Front. Educ.* 7:950766. doi: 10.3389/feduc.2022.950766

Badet, J. (2021). AI, automation and new jobs. *Op. J. Bus. Manag.* 9, 2452–2463. doi: 10.4236/ojbm.2021.95132

Balliester, T., and Elsheikhi, A. (2018). The Future of Work: A Literature Review. Available at: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---inst/documents/publication/wcms_625866.pdf

Belpaeme, T., Kennedy, T., Ramachandran, A., Scassellati, B., and Tanaka, F. (2018). Social robots for education: A review. *Sci Robot* 3, 1–9. doi: 10.1126/scirobotics.aat5954

Bowman, E. (2023). A College Student Created an App That Can Tell Whether AI Wrote An Essay. Available at: https://www.npr.org/2023/01/09/1147549845/gptzero-ai-chatgpt-edward-tian-plagiarism

Butler-Adam, J. (2018). The fourth industrial revolution and education. *S. Afr. J. Sci.* 114:1. doi: 10.17159/sajs.2018/a0271

Butt, R., Siddiqui, H., Soomro, R. A., and Asad, M. A. (2020). Integration of Industrial Revolution 4.0 and IoTs in academia: A state-of-the-art review on the concept of Education 4.0 in Pakistan. *Interact Technol Smart Educ* 17, 337–354. doi: 10.1108/ITSE-02-2020-0022

Care, E., Kim, H., Anderson, K., and Gustafsson-Wright, E. (2017). *Skills for a Changing World: National Perspectives and the Global Movement*. Available at: https://www.brookings.edu/wp-content/uploads/2017/03/global-20170324-skills-for-a-changing-world.pdf

Catană, S.-A., Toma, S.-G., and Barbu, A. (2021). The effects of the COVID-19 pandemic on teleworking and education in a Romanian higher education institution: An internal stakeholders perspective. *Int. J. Environ. Res. Public Health* 18:8180. doi: 10.3390/ijerph18158180

CERI (2008). *21st Century Learning: Research, Innovation and Policy: Directions from Recent OECD Analyses*. Available at: https://www.oecd.org/site/educeri21st/40554299.pdf

Chaka, C. (2009). "Portable handheld language learning: From CALL, MALL to PALL" in *Handbook of Research on E-Learning for Language Acquisition*. eds. R. V. Marriott and P. L. Torres (Santa Rosa, CA: Informing Science Press), 550–564.

Chaka, C. (2010a). "Education 2.0: Pedagogy and teacher-learner transformation" in *Smart Teaching: A Transformational Approach*. ed. T. Swain (New Delhi: DK Fine Art Press), 18–51.

Chaka, C. (2010b). "E-learning 2.0: Web 2.0, the Semantic Web and the power of collective intelligence" in *Handbook of Research on Practices and Outcomes in E-Learning: Issues and Trends*. eds. S. Yuen and H. Yang (Hershey: IGI Global), 38–60.

Chaka, C. (2010c). "Enterprise 2.0: Leveraging Prosumerism 2.0 using Web 2.0 and Web 3.0" in *Handbook of Research on Web 2.0, 3.0 and X.0: Technologies, Business, and Social Applications*. ed. S. Murugesan, vol. *I* (Hershey, PA: IGI Global), 630–646.

Chaka, C. (2011). "Research on Web 2.0 digital technologies in education" in *Digital Education: Opportunities for Social Collaboration*. ed. M. Thomas (London/Basingstoke: Palgrave Macmillan), 37–59.

Chaka, C. (2019). Re-imagining literacies and literacies pedagogy in the context of semio-technologies. *Nordic J. Digit. Lit.* 14, 53–68. doi: 10.18261/issn.1891-943x-2019-0102-05

Chaka, C. (2020). Skills, competencies and literacies attributed to 4ir/industry 4.0: scoping review. *IFLA J.* 46, 369–399. doi: 10.1177/0340035219896376

Chaka, C. (2021). COVID-19 as a prime driver of rapid technological experimentation in higher-education teaching and learning: an overview of reviews. *Zeitschrift für Hochschulentwicklung.* 16, 17–36. doi: 10.3217/zfhe-16-03/02

Chaka, C. (2022a). Is Education 4.0 a sufficient innovative, and disruptive educational trend to promote sustainable open education for higher education institutions? A review of literature trends. *Front. Educ.* 7:824976. doi: 10.3389/feduc.2022.824976

Chaka, C. (2022b). Higher education institutions and the use of online instruction and online tools and resources during the COVID-19 outbreak—An online review of selected U.S. and SA's universities. *Res Square*, 1–46. doi: 10.21203/rs.3.rs-61482/v1

Chaka, C. (2022c). Educational data mining, student academic performance prediction, prediction methods, algorithms and tools: An overview of reviews. *J. E-Learn. Know. Soc.* 18, 58–69. doi: 10.20368/1971-8829/1135578

Chaka, C. (2022d). Digital marginalization, data marginalization, and algorithmic exclusions: A critical southern decolonial approach to datafication, algorithms, and digital citizenship from the Souths. *J. E-Learn. Know. Soc.* 18, 83–95. doi: 10.20368/1971-8829/1135678

Chaka, C. (2023). Fourth industrial revolution—a review of applications, prospects, and challenges for artificial intelligence, robotics and blockchain in higher education. *Res. Prac. Tech. Enhan. Learn.* 18, 1–39. doi: 10.58459/rptel.2023.18002

Chaka, C., and Mashige, M. C. (2016). Revisiting the postmodern condition of a higher education landscape: South Africa's higher education epochal archive, 1999–2002. *J. High. Educ. Africa.* 3, 19–44.

Chaka, C., Nkhobo, T., and Lephalala, M. (2022). Leveraging student engagement through MS Teams at an open and distance e-learning institution. *J. Educ. E-Learn. Res.* 9, 136–146. doi: 10.20448/jeelr.v9i3.4102

Change Recruitment (2017). *How Will the Fourth Industrial Revolution Impact the Future of Work?* Available at: https://www.changerecruitmentgroup.com/knowledge-centre/how-will-the-fourth-industrial-revolution-impact-the-future-of-work

ChatGPT (2023). *ChatGPT, what are you, and how different are you from the other chatbots?* Available at: https://chat.openai.com/chat

Couldry, N., and Mejias, U. A. (2019). Data colonialism: Rethinking big data's relation to the contemporary subject. *Telev. N. Med.* 20, 336–349. doi: 10.1177/1527476418796632

Cutcliffe, J. (2022). *ChatGPT, Chatbots and Artificial Intelligence in Education*. Available at: https://ditchthattextbook.com/ai/

Da Silva, L. B. P., Soltovski, R., Pontes, J., Treinta, F. T., Leitão, P., Mosconi, E., et al. (2022). Human resources management 4.0: literature review and trends. *Comp. Indus. Engin.* 168:108111, 1–20. doi: 10.1016/j.cie.2022.108111

Dede, C. (2005). Planning for neo-millennial learning styles. *Educ. Q.* 28, 7–12.

Dede, C. (2009). *Comparing Frameworks for "21st Century Skills"*. Available at: https://allchildrenlearning.org/wp-content/uploads/2019/12/Dede_2010_Comparing-Frameworks-for-21st-Century-Skills.pdf

Deloitte. (2018). *Preparing Tomorrow's Workforce for the Fourth Industrial Revolution for Business: A Framework for Action*. Available at: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/About-Deloitte/gx-preparing-tomorrow-workforce-for-4IR.pdf

Elayyan, S. (2021). The future of education according to the fourth industrial revolution. *J. Educ. Techn. Onl. Learn.* 4, 23–30. doi: 10.31681/jetol.737193

Evans, C., and Robertson, W. (2020). The four phases of the digital natives debate. *Hum. Behav. Emerg. Tech.* 2, 269–277. doi: 10.1002/hbe2.196

Filippi, E., Bannò, M., and Trento, S. (2023). Automation technologies and their impact on employment: A review, synthesis and future research agenda. *Technolog. Fore. Soc. Chang.* 191:122448. doi: 10.1016/j.techfore.2023.122448

Frey, C. B., and Osborne, M. A. (2013). *The Future of Employment: How Susceptible Are Jobs to Computerisation?* Available at: https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

Govender, C. M., and Adegbite, W. M. (2022). Evolving role of learning and development specialists in the 21st century fourth industrial revolution workplace. *Int. J. Entre.* 26, 1–16.

Harris, M. (2022). *ChatGPT—The Game-Changing App Every Teacher Should Know About*. Available at: https://www.learnersedge.com/blog/chatgpt-the-game-changing-app-every-teacher-should-know-about

Heilweil, R. (2022). *AI Is Finally Good at Stuff, and That's a Problem*. Available at: https://www.vox.com/recode/2022/12/7/23498694/ai-artificial-intelligence-chat-gpt-openai

Helfat, C. E. (2007). Stylized facts, empirical research and theory development in management. *Strat. Organ.* 5, 85–192. doi: 10.1177/1476127007077559

Hern, A. (2022). *AI Bot ChatGPT Stuns Academics with Essay-Writing Skills and Usability*. Available at: https://www.theguardian.com/technology/2022/dec/04/ai-bot-chatgpt-stuns-academics-with-essay-writing-skills-and-usability

Hewson, E., and Chung, G. W. (2021). Beyond the VLE: Transforming online discussion and collaboration through Microsoft Teams. *Int. J. Man. Sci. Bus. Admin.* 7, 37–45. doi: 10.18775/ijmsba.1849-5664-5419.2014.73.1004

Hirschman, D. (2016). Stylized facts in the social sciences. *Soc. Sci.* 3, 604–626. doi: 10.15195/v3.a26

Illori, M. O., and Ajagunna, I. (2020). Re-imagining the future of education in the era of the fourth industrial revolution. *World. Hosp. Tour. Them.* 12, 3–12. doi: 10.1108/WHATT-10-2019-0066

Joynes, C., Rossignoli, S., and Amonoo-Kuofi, E. F. (2019). *21st Century Skills: Evidence of Issues in Definition, Demand and Delivery for Development Contexts*. Available at: https://assets.publishing.service.gov.uk/media/5d71187ce5274a097c07b985/21st_century.pdf

Kaldor, N. (1961). "Capital accumulation and economic growth" in *Theory of Capital*. eds. F. A. Lutz and D. C. Hague (London: Macmillan), 177–222.

Keser, H., and Semerci, A. (2019). Technology trends, Education 4.0 and beyond. *Cont. Educ. Res. J.* 9:39. doi: 10.18844/cerj.v9i3.4269

Khadragy, S. (2022). Artificial Intelligence and the future of employment: a systematic review of the state of the art literature. *Int. J. Mech. Engin.* 7, 3118–3125.

Kibe, L., Kwanya, T., and Nyagowa, H. (2023). Harnessing fourth industrial revolution (4IR) technologies for sustainable development in Africa: A meta-analysis. *Technol Sustain*. doi: 10.1108/TECHS-01-2023-0004

Lambert, M. (2002). *21st Century Learners—and Their Approaches to Learning*. Available at: https://www.academia.edu/980897/21st_century_learners_and_their_approaches_to_learning

Lepasepp, T. K., and Hurst, W. A. (2021). Systematic literature review of industry 4.0 technologies within medical device manufacturing. *Fut. Inter.* 13, 1–19. doi: 10.3390/fi13100264

Li, L. (2022). Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. *Info. Sys. Front.*, 1–16. doi: 10.1007/s10796-022-10308-y

Luckin, R., Holmes, W., Griffiths, M., and Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Educatio*n. Available at: https://edu.google.com/pdfs/Intelligence-Unleashed-Publication.pdf

Lyotard, J.-F. (1984). *The Postmodern Condition: A Report on Knowledge* (Bennington, T. G. & B. Massumi), Minnneapolis: University of Minnesota Press.

Marlin, D. (2018). *Millennials, This Is How Artificial Intelligence Will Impact Your Job for Better and Worse*. Available at: https://www.forbes.com/sites/danielmarlin/2018/01/16/millennials-this-is-how-artificial-intelligence-will-impact-your-job-for-better-and-worse/#164ba5e44533

Masriadi, D., Ekaningrum, N. E., Hidayat, M. S., and Yuliaty, F. (2023). Exploring the future of work: Impact of automation and artificial intelligence on employment. *EJ* 6, 125–136. doi: 10.54783/endlessjournal.v6i1.131

McKinsey Global Institute. (2018). *AI, Automation, and the Future of Work: Ten Things to Solve for*. Available at: https://www.mckinsey.com/~/media/mckinsey/featured%20insights/future%20of%20organizations/ai%20automation%20and%20the%20future%20of%20work%20ten%20things%20to%20solve%20for/mgi-briefing-note-ai-automation-and-the-future-of-work_june2018.pdf

Meghmala. (2023). *GPTZero: An App to Detect Whether Text is Written by ChatGPT*. Available at: https://www.analyticsinsight.net/gptzero-an-app-to-detect-whether-text-is-written-by-chatgpt/#:~:text=Student%2Dmade%20app%20GPTZero%20determinesfor%20unethical%20usage%20in%20academia.

Mendritzki, S. (2014). To stylize or not to stylize, is it a fact then? Clarifying the role of stylized facts in empirical model evaluation. *J. Econ. Method.* 21, 107–124. doi: 10.1080/1350178X.2014.907439

Mitchell, R., Shen, Y., and Snell, L. (2021). The future of work: A systematic literature review. *Account. Fin.* 62, 2667–2686. doi: 10.1111/acfi.12878

Moldoveanu, I. (2022). Managing the impact of digital transformation on the future of jobs—a sectoral approach—a semi-systematic literature review. *Rev. Int. Comp. Manag.* 23, 439–453. doi: 10.24818/RMCI.2022.3.439

Morgan, J. (2007). The new basics: changing curriculum for 21st century skills. *Visio. Look. Fut. Learn.* 4, 9–11. Retrieved from: https://www.nfer.ac.uk/media/1853/futl90.pdf

Mury, S. R., Negrini, L., Assaf, D., and Skweres, M. (2022). How to support teachers to carry out educational robotics activities in school? The case of Roteco, the Swiss robotic teacher community. *Front. Educ.* 7:968675. doi: 10.3389/feduc.2022.968675

Nasreen, F., Halili, S. H., and Razak, R. A. (2022). Employability skills of Malaysian university students for IR4: A systematic literature review. *Malay. Onl. J. Educ. Manag.* 10, 15–28.

NCTE. (2007). *21st-Century Literacies* (A Policy Research Brief). Available at: https://cdn.ncte.org/nctefiles/resources/policyresearch/21stcenturyclips.pdf

NCTE. (2008). *NCTE Framework for 21st Century Curriculum and Assessment*. Available at: https://cdn.ncte.org/nctefiles/resources/positions/framework_21stcent_curr_assessment.pdf

Nedelkoska, L., and Quintini, G. (2018). Automation, skills use and training. *OECD Soc. Employ. Migrat. Work. Papers* 202, 1–124. doi: 10.1787/2e2f4eea-en

Oosthuizen, R. M. (2022). The fourth industrial revolution—smart technology, artificial intelligence, robotics and algorithms: Industrial psychologists in future workplaces. *Front. Artif. Intell.* 5:913168. doi: 10.3389/frai.2022.913168

Partnership for 21st Century Skills. (2008). *21st Century Learning Environments*. Available at: http://www.21stcenturyskills.org/documents/le_white_paper-1.pdf

Peixoto, B., Pinto, R., Melo, M., Cabral, L., and Bessa, M. (2021). Immersive virtual reality for foreign language education: A PRISMA systematic review. *IEEE Acc.* 9, 48952–48962. doi: 10.1109/ACCESS.2021.3068858

Pennsylvania Department of Education. (2008). *21st Century Workplace: Skills for Success*. Available at: http://bb.plsweb.com/PDEcourses/T21-NFC/course_attachments/m1tE_02.pdf (Accessed 10 December 2022).

Pianta, M. (2018). Technology and Employment: Twelve Stylised Facts for the Digital Age. *Indian J. Labour Econ.* 61, 189–225. doi: 10.1007/s41027-018-0124-5

Pianta, M. (2020). "Technology and work: Key stylized facts for the digital age" in *Handbook of Labor, Human Resources and Population Economics*. ed. K. F. Zimmermann (Cham: Springer)

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the Horizon* 9, 1–6. doi: 10.1108/10748120110424816

Reaves, J. (2019). 21st-century skills and the fourth industrial revolution: a critical future role for online education. *Int J Innov Online Edu* 3, 1–17. doi: 10.1615/IntJInnovOnlineEdu.2019029705

Solé, E. (2023). *Teachers Sound Off on ChatGPT, the New AI Tool That Can Write Students' Essays for Them*. Available at: https://www.today.com/parents/teens/chatgpt-ai-teachers-students-cheat-essays-rcna63352

Spires, H., and Annetta, L. (2008). *21st Century Skills and Serious Games: Preparing the N Generation*. Available at: https://www.researchgate.net/profile/Hiller-Spires/publication/309547229_21st_century_skills_and_serious_games_Preparing_the_N_generation/links/58d9a49ca6fdccca1c4c00cf/21st-century-skills-and-serious-games-Preparing-the-N-generation.pdf

Stokel-Walker, C. (2022). AI Bot Chatgpt Writes Smart Essays — Should Professors Worry? *Nature*. doi: 10.1038/d41586-022-04397-7

Stuart, L., and Dahm, E. (1999). *21st Century Skills for 21st Century Jobs*. Available at: https://ecommons.cornell.edu/bitstream/handle/1813/78287/21stCenturySkillsJobs.pdf?sequence=1&isAllowed=y

Tangermann, V. (2023). *There's a Problem with That App That Detects GPT-Written Text: It's Not Very Accurate*. Available at: https://futurism.com/gptzero-accuracy

The Economist. (2018). *A Study Finds Nearly Half of Jobs Are Vulnerable to Automation*. Available at: https://www.economist.com/graphic-detail/2018/04/24/a-study-finds-nearly-half-of-jobs-are-vulnerable-to-automation

Thomas, M. (2022). *Robots and AI Taking over Jobs: What to Know About the Future of Jobs*. Available at: https://builtin.com/artificial-intelligence/ai-replacing-jobs-creating-jobs

Uenuma, F. (2019). *20 Years Later, the Y2K Bug Seems Like a Joke—Because Those Behind the Scenes Took It Seriously*. Available at: https://time.com/5752129/y2k-bug-history/

Whitby, G. B. (2007). *Pedagogies for the 21st Century: Having the Courage to See Freshly*. Available at: https://robertsonss.eq.edu.au/Supportandresources/Formsanddocuments/Documents/pedagogy-for-the-21st-century.pdf

White House. (2022). *The Impact of Artificial Intelligence on the Future of Workforces in the European Union and the United States of America*. Available at: https://www.

whitehouse.gov/wp-content/uploads/2022/12/TTC-EC-CEA-AI-Report-12052022-1.pdf

Wichmann, R. L., Boris, E., and Kilian, G. (2019). *The Direction of Industry: A Literature Review on Industry 4.0*. Available at: https://www.cambridge.org/core/services/aop-cambridgecore/content/view/8289BD1A23A149EC632B05232A45738B/S2220434219002191a.pdf/the-direction-of-industry-a-literature-review-on-industry-40.pdf

Wiggers, K. (2023). *OpenAI Begins Piloting ChatGPT Professional, a Premium Version of Its Viral Chatbot*. Available at: https://techcrunch.com/2023/01/11/openai-begins-piloting-chatgpt-professional-a-premium-version-of-its-viral-chatbot/

Williamson, B., Macgilchrist, F., and Potter, J. (2023). Re-examining AI, automation and datafication in education. *Learn. Media Technol.* 48, 1–5. doi: 10.1080/17439884.2023.2167830

Yancey, K. B. (2009). *Writing in the 21st Century*. Available at: https://cdn.ncte.org/nctefiles/press/yancey_final.pdf

Yusuf, B., Walters, L. M., and Sailin, S. N. (2020). Restructuring educational institutions for growth in the fourth industrial revolution (4IR): a systematic review. *Int. J. Emerg. Educ. Technol.* 15, 93–109. doi: 10.3991/ijet.v15i03.11849

Zawacki-Richter, O., Marín, V. I., Bond, M., and Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – Where are the educators? *Int. J. Educ. Technol. High. Educ.* 16, 1–27. doi: 10.1186/s41239-019-0171-0

Zembylas, M. (2021). A decolonial approach to AI in higher education teaching and learning: Strategies for undoing the ethics of digital neo-colonialism. *Learn. Media Technol.* 48, 1–13. doi: 10.1080/17439884.2021.2010094

Zervoudi, E. K. (2020). *Fourth industrial revolution: Opportunities, challenges, and proposed policies*. London:IntechOpen. doi: 10.5772/intechopen.90412