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Education 4.0: Exploring computer science teachers' readiness

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Abstract

Due to the pivotal roles played by Education 4.0 in reshaping the skills necessary for sustenance in the 4th Industrial Revolution (4IR), we investigate computer science teachers' preparedness to acquire the requisite skills for effectively equipping students with skills, especially technology skills for the life and work of 4IR. Teachers play crucial roles in preparing students for a technology-driven world. Examining their readiness to acquire skills for effective delivery of Education 4.0's skills-based content becomes imperative. Prior to data collection, the teachers underwent a tailored professional development training focusing on 4IR, Education 4.0, and the required skills. Our findings reveal an overall positive disposition of the teachers towards acquiring the skills needed to fulfil the roles demanded by Education 4.0. This finding reiterates the importance of professional development initiatives to assist teachers in meeting the skills requirements and also face the challenges of Education 4.0. Consequently, we advocate for interventions tailored to address the specific needs of teachers, enabling them to embrace the evolving responsibilities associated with Education 4.0.

Keywords: Education 4.0, 4th Industrial Revolution, computer science, teachers' readiness

INTRODUCTION

The past industrial revolutions have been the singular, and most important developments in the history of humanity over the past three centuries. Industrial revolutions are characterized by transformative innovations and paradigm shifts, fundamentally reshaping societal structures and human modes of existence (Stearns, 2018). The 1st Industrial Revolution, spanning the 18th and 19th centuries, witnessed the transition from manual agricultural practices to mechanized processes. Notably, the invention of the steam engine during this period revolutionized the means of production, triggering a substantial impact on societies worldwide. Concurrently, the era saw significant advancements in infrastructure, thereby laying the foundation for economic development and diversification across nations. Subsequently, the 2nd Industrial Revolution (the 19th century) emerged with other remarkable strides in electricity, steel, and chemical technologies (Agarwal & Agarwal, 2017). This period marked a continued trajectory of technological innovation, further influencing the global landscape. In addition, the onset of the 3rd Industrial Revolution in the mid-1900s was characterized by technological breakthroughs in the manufacturing, distribution, and energy sectors. Key developments during this era included the widespread adoption of electronics and the emergence of nuclear power as significant contributors to societal progress (Kayembe & Nel, 2019). The first three industrial revolutions share a common thread of technological advancement as their defining characteristic. These revolutions have played a pivotal role in shaping the socio-economic and cultural fabric of human civilization over the past three centuries.

The 4th Industrial Revolution (4IR), also 4.0 era, signifies a pivotal advancement in technology, ushering

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Contribution to the literature

- This study contributes valuable insights into the challenges and opportunities associated with Education 4.0 and emphasizes the importance of tailored interventions to address the specific needs of teachers.
- The positive disposition observed among the teachers underscores the effectiveness of professional development in enhancing educators' competencies to meet the demands of Education 4.0.
- The findings reveal a positive disposition among teachers towards acquiring the skills needed for the evolving educational landscape, highlighting the significance of targeted professional development initiatives.

in a transformative era marked by cutting-edge innovations. Key elements of this period include advanced robotics, the Internet of things (IoT), artificial intelligence (AI), ubiquitous computing, augmented and virtual realities, bring your own device, wearables, and additive manufacturing, among other paradigm-shifting developments. The impact of these changes is pervasive, altering daily production processes, restructuring business models, and revolutionizing educational approaches on a global scale (World Economic Forum, 2017). 4IR is fundamentally a digital revolution already underway in certain regions. Europe and the USA, for instance, have initiated 4IR era, witnessing the early stages of automation and process digitization. However, this progress has sparked concerns about the potential obsolescence of traditional employment, echoing the apprehensions expressed by Rifkin (1995) regarding the "end of work." Building on the successes of preceding industrial revolutions, 4IR ushers in a new wave of challenges that demand innovative solutions. As the world transitions from one revolution to the next, 4IR introduces more sophisticated emerging technologies, novel ideas, and possibilities, as well as a plethora of intricate challenges (Kayembe & Nel, 2019). It is within this dynamic landscape that researchers and innovators are striving to devise strategies that harness the potential benefits of this era while also addressing the challenging complexities inherent in 4IR.

The emergence of 4IR is significantly reshaping educational principles across all levels, as highlighted by Ilori and Ajagunna (2020). This era is marked by disruptive innovations, methodologies, and technologies, notably AI, machine learning (ML), and algorithms, as emphasized by Chaka (2020) and González-Pérez and Ramírez-Montoya (2022). Hence, the integration of 4IR framework–encompassing Industry 1.0 (mechanization, steam, and waterpower), Industry 2.0 (mass production and electricity), Industry 3.0 (electronic and IT systems, automation), and Industry 4.0 (cyber-physical systems)–within this investigation offers crucial historical context and highlights the synergies between industrial and educational technological advancements (see **Figure 1**).

By understanding the trajectory of industrial revolutions, teachers can anticipate and adjust to the changing requisites of the digital era, thereby arming students with the essential proficiencies and capabilities vital for thriving in a progressively technology-driven global landscape (Teo et al., 2021). Given the background, our study explores the readiness level of computer science teachers to acquire skills for education in 4IR, while also considering demographic variables such as gender and years of experience.

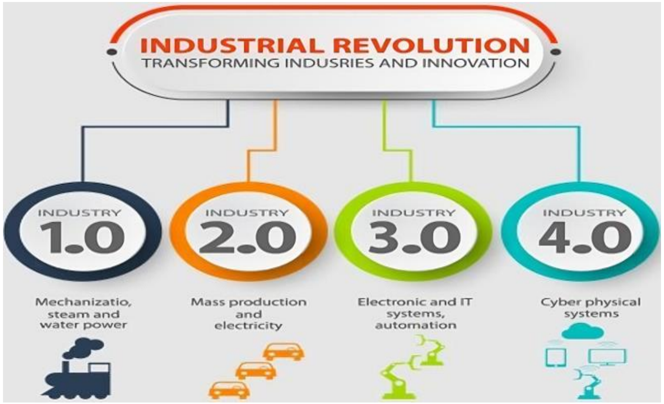

Figure 1. Industrial revolutions (https://digitalrise.id/2021/02/09/entry-with-audio/)

LITERATURE REVIEW

Education 4.0, Industry 4.0, & Skills Demand

Learning paradigms in the 21st century is being revolutionized at a faster pace by 4IR, and this is due to its significant impact on almost all spheres of human life. There is no doubt that 4IR era will continue to bring dramatic changes in education through far more powerful and smart technologies, and this has led to what has come to be known as Education 4.0. Education 4.0, as highlighted by James (2019), entails an educational system aligning itself with the unfolding era of 4IR. It emphasizes intelligent technologies that have seamlessly integrated into the fabric of human daily life. In Education 4.0, dramatic and unpopular changes are already taking place in instructional processes like never seen before. For instance, as a form of instructional strategy in the 21st century, AI-based tutoring systems are quickly gaining ground as the world goes deeper into 4IR (Adelana & Akinyemi, 2021; Ayanwale et al., 2022a). As the advancements continue, the significance of smart technologies and information and communication technologies (ICTs) becomes increasingly profound across all aspects of human existence.

Figure 2. Top-10 skills Education 4.0 demands (http://www.mentornets.in/education)

Now that AI technologies are swiftly becoming a part of human daily routines, discussions about the technology among teachers continues to gain popularity (Ishola et al., 2022; Yang, 2019; Zimmerman, 2018).

Figure 2 serves as a cornerstone for understanding the skills landscape essential to Education 4.0. By delineating these specific proficiencies, spanning from intricate problem-solving to cognitive adaptability, this study delivers a comprehensive overview of the multifaceted competencies imperative in the evolving educational sphere. Anticipating the changes ushered in by Industry 4.0 is pivotal, as it illuminates the novel tasks teachers and learners must undertake, along with the additional skills demanded of them. The competencies and aptitudes of learners, in particular, should mirror societal challenges and employer requisites. Hence, to embrace Industry 4.0, soft skills such as creativity, critical thinking, intercultural proficiency, and teamwork prowess are indispensable (do Rosário Cabrita et al., 2020).

As the work environment and tools evolve, so too will the required skills. Learners must possess both broad and specialized knowledge in fields like mathematics, engineering, management, and science. Given the global nature of contemporary challenges, interdisciplinary thinking will be paramount in navigating the continual transformations in the economic, social, and environmental spheres of Industry 4.0 (do Rosário Cabrita et al., 2020).

The advent of Industry 4.0 in manufacturing not only heralds a technological revolution but also necessitates a shift from traditional education to more advanced methods, encapsulated in the concept of Education 4.0. Human skills must undoubtedly undergo enhancement to adeptly manage key enabling technologies such as cyber-physical systems, augmented reality, human-robot collaboration, and smart devices (Mourtzis, 2018). Increasingly, workforce preparedness will emphasize not just knowledge acquisition but also the ability to demonstrate synthesis and application, alongside interoperability and integration of this knowledge with new technologies (Hong & Ma, 2020).

Figure 2 acts as a guiding framework for evaluating the readiness of computer science teachers, providing a concrete yardstick for assessing their ability to tackle the challenges and opportunities of Education 4.0. Furthermore, it highlights the pressing need for teachers to adapt and acquire these competencies to effectively engage with contemporary pedagogical approaches, ensuring the pertinence and effectiveness of their teaching methods in an increasingly interconnected and technology-centric environment.

Education 4.0 underscores the significance of cultivating practical collaborative problem-solving skills, interdisciplinary proficiency, and adaptability, all of which are required skills aligning with the dynamic demands of future job markets. Within this paradigm, computer science assumes a pivotal role, necessitating its evolution to incorporate these principles.

Across diverse learning domains, students must be adeptly trained to acquire relevant digital skills and literacies, positioning them for success in 4IR era, and beyond (Anggraeni, 2018). This underscores the importance for teachers to equip themselves with the requisite expertise to meet the challenges presented by Education 4.0 and its evolving curricula. As 4IR continues to redefine societal norms with a technology-centric focus, industries increasingly demand proficiency in emergent technologies like AI, blockchain, and automation. Consequently, teachers must possess relevant skills to impart up-to-date knowledge that fosters critical thinking and problem-solving abilities–essential competencies for the future workforce.

Furthermore, the intersection of 4IR technologies with various fields necessitates teachers to bridge the gap between theoretical knowledge and practical application, integral to Education 4.0 curricula. Embracing 4IR skills transforms computer science teachers into catalysts for innovation, enabling them to prepare students for navigating a continually evolving digital landscape. This proactive approach not only equips students for future challenges but also positions teachers as key contributors to a society increasingly reliant on emerging and advanced technologies.

Currently, there is a concept termed Teacher 4.0, designed for future teachers who possess versatility in managing and incorporating emerging technologies within their classrooms (Abdelrazeq et al., 2016).

In 4IR era, and Education 4.0 particularly, it is imperative to transform the computer science curricula to align education with the evolving demands for skills in 4IR. The traditional computer science curriculum, especially in the context of Nigeria, is not adequate in addressing the dearth of skills, and therefore not adequate in training students for skills acquisition for emerging technologies such as ML, AI, and blockchain–which are some of the central themes of 4IR.

By adapting the present computer science curricula to aligns with the principles of Education 4.0, teachers and stakeholders will not just be preparing students for the demands of modern jobs and workplaces but will also be promoting the integration of real-world applications and industry-relevant projects into the curriculum, thereby enhancing students' practical skills, development of ethical considerations, and promoting responsible and sustainable use of emerging technologies.

In addition, embedding the principles of Education 4.0 into the computer science curricula, and preparing teachers to be ready to teach them will ensure that students are not only technically proficient but also acquire relevant skills such as communication, critical thinking, collaboration, and real-world problem-solving skills, among others, all of which are imperative for successful living and the jobs of the digital age.

As a result of this significant paradigm shift in education, the need arises to train students who can navigate the complexities of 4IR, driving innovation, and contributing meaningfully to the global technological landscape.

However, this can only be made possible by teachers who are themselves prepared to and ready with such skills to facilitate their students. In view of this, it is not enough to overhaul the present computer science curricula in Nigeria, but also that teachers must be extensively trained to acquire skills for Education 4.0 via extensive professional development programs (Junid et al., 2019).

4IR & Its Implication for Teachers' Professional Development

Integration of emerging technologies such as AI into K-12 education leads to fresh challenges for key stakeholders, especially teachers who are key players in shaping the teaching and learning dynamics (Ayanwale et al., 2022b). Varying empirical reports abound on 4IR and its implications for education. The level of readiness of teachers to embrace the technologies of 4IR is worthy of studying. It will not be enough for teachers to just have specialty knowledge in 4IR era, but also that training be increased for teachers, especially those in STEM education (Ayanwale, 2023; Corlu et al., 2014; Eroglu & Bektas, 2016; Ercan, 2014; Oladele et al., 2022). All teachers need to understand the various and diverse factors that are essential for implementing successful computer science education in 4IR because success also requires that teachers acquire skills for implementing and managing education and working with new technologies and their colleagues. This was corroborated by Gray (2016), who proposed that very soon, almost 35.0% of skills rated important today will be redundant and eventually change. Because of this, an emerging skill set will be essentially required by the changes influenced by 4IR and the use of emerging technologies. However, Kayembe and Nel (2019) were quick to point out that 4IR comes with concerns that are tied to the utilization of emerging technologies. They cautioned that conscious planning be put in place to manage the concerns.

Nevertheless, Hu and Garimella (2014) noted a significant shortfall among teachers in effectively integrating emerging technologies into their curriculum. This observation aligns with the findings of Newhouse (2002), who earlier reported that many teachers not only lack the requisite knowledge and skills for utilizing technologies but also exhibit a lack of enthusiasm for the transformative changes introduced by the 21st century technologies.

Supporting teachers in achieving excellence in their roles necessitates enhancing their skills through professional development initiatives, encompassing both structured and spontaneous opportunities for growth and advancement within the profession (Mukeredzi, 2016). The imperative for ongoing professional development among teachers, especially in multicultural or multilingual educational settings, stems from the escalating cultural and ethnic diversity observed in classrooms (Organization for Economic Co-operation and Development [OECD], 2019). While literacy traditionally entailed the acquisition of reading skills, in the 21st century, it extends to reading for comprehension, encompassing the ability and motivation to discern, comprehend, interpret, generate, and communicate knowledge using written materials across diverse and evolving contexts.

Moreover, literacy entails fostering curiosity, self-directed learning, adept navigation of non-linear information structures, synthesis of information, tolerance for ambiguity, cultivation of critical thinking, inquiry-based learning, and resolution of conflicting information (OECD, 2010). Education 4.0 mandates that teachers become highly knowledgeable individuals who continually advance their professional expertise and contribute to innovation within their field. Teachers must serve as catalysts for innovation, as they play a pivotal role in fostering growth, efficiency, and productivity in the education sector. Innovation, applied to both curriculum development and teaching methodologies, holds the potential to enhance learning outcomes and equip students with the requisite skills to thrive in the dynamically evolving landscape of the 21st century labor market (OECD, 2010).

As highlighted by Duggan (2020), continual and effective professional learning stands as a cornerstone for teachers, enabling schools to nurture the increasingly intricate skills vital for students' advancement in further education and their future careers in the 21st century. To cultivate these indispensable skills in students, teachers must possess sophisticated teaching methodologies aimed at fostering competencies such as critical thinking, complex problem-solving, deep understanding of challenging subjects, effective communication and collaboration, and self-directed learning. Essentially, teachers require support in honing the pedagogical approaches necessary for imparting these skills, underscoring the significance of professional development (Duggan, 2020; Oladele et al., 2023). Research by Liu et al. (2015) suggests that quality professional development can significantly enhance teachers' skills and consequently influence their teaching practices. Effective professional development interventions may particularly target the enhancement of teachers' values alongside technological skills (Ayanwale et al., 2023; Bowman et al., 2020; Kim et al., 2017). Within the scope of this study, gender considerations emerge as crucial due to their impact on instructional technology utilization. Investigating gender differences becomes imperative as it may unveil existing disparities (Siddiq & Scherer, 2019), catalyzing bridging these gaps and addressing inequalities. Li (2016) indicates that while male teachers initially exhibited more positive attitudes and confidence in technology use compared to their female counterparts, participation in professional development programs led to an enhanced integration of technology by female teachers, diminishing this difference. Conversely, Javier (2020) suggests that male teachers tended to assess themselves as less competent in technology compared to their female counterparts, although statistically, this difference was insignificant. Moreover, Antonio et al. (2020) concluded that a gender divide exists in technological competence, with female teachers surpassing male teachers in this aspect. Mahdi and Dera (2013) highlighted a gender-dependent reliance on ICT experts, predominantly male teachers, by their female counterparts when technical issues arise in the use of educational technologies.

According to Gebhardt et al. (2019), female teachers who effectively utilize technology serve as influential role models for young girls in schools. However, research indicates that female teachers are less inclined to utilize ICTs compared to their male counterparts. Nevertheless, when it comes to the pedagogical use of ICT in secondary schools, the disparity between male and female teachers appears to be relatively minor. Additionally, Mahdi and Dera (2013) highlight significant gender-based discrepancies in ICT proficiency, favoring male teachers. Some scholars argue that the competencies essential for online teaching do not substantially differ from those required for traditional face-to-face instruction, positing that prior teaching experience lays the groundwork for online teaching (Bawane & Spector, 2009; Wray et al., 2008). Contrarily, Semerci and Aydin (2018) found no significant difference in teachers' ICT use based on their teaching experience. Irrespective of demographic factors, the evolving demand for skills has profound implications for the competencies teachers must acquire to effectively impart the 21st century skills to students. In today's digital age, where information is readily accessible via search engines, routine knowledge is digitized or outsourced, and job roles are swiftly evolving, teachers play a pivotal role in fostering lifelong learning and nurturing complex cognitive and work skills that computers cannot easily emulate (OECD, 2010). Notably, the extent and quality of ICT implementation in teaching and learning largely hinge on teachers' instructional design decisions (König et al., 2022). As teachers' perceived barriers, internal beliefs, and technology integration behaviors are closely intertwined, changes in barriers and behaviors may also be interlinked (Xie et al., 2023). Kopcha et al. (2020) argue that technology integration entails decision-making processes within a dynamic system, where teacher perceptions, beliefs, and behaviors interact and evolve.

There is a deficit in innovative talents and skills, particularly in developing and underdeveloped countries, Nigeria inclusive. This deficit poses a hindrance to fully capitalizing on the opportunities presented by Education 4.0 in 4IR. The study emphasizes the importance of educational systems, especially in 4IR era, to transcend conventional knowledge-centric training and prioritize the cultivation of innovative skills. This shift is crucial for nurturing individuals capable of driving economic progress and addressing the multifaceted challenges of 4IR era. Teachers need to be prepared to adjust their roles and responsibilities in response to the evolving educational processes of 4IR.

According to Gebhardt et al. (2019), the beliefs and attitudes of teachers towards ICTs in teaching and learning are central to the successful implementation of new technologies. While teachers are encouraged to integrate ICT into their teaching, there is evidence that the effectiveness of this integration depends to a large extent on teachers' preparedness to do so, which is directly related to their confidence and knowledge in using ICT, as well as their beliefs about the value of ICT in education. This study answers following questions:

RQ1. What is level of computer science teachers' readiness to acquire skills for education in 4IR?

RQ2. Is there a significant statistical difference in the level of computer science teachers' readiness to acquire skills for education in 4IR based on gender?

RQ3. Is there a significant statistical difference in the level of computer science teachers' readiness to acquire skills for education in 4IR based on years of experience?

METHODOLOGY

The research was conducted to explore the preparedness of computer science teachers for Education 4.0 in an educational division in a Southwest State in Nigeria. The division holds significance as being one of the most active division in terms of providing professional development training for its teachers via its teachers' professional association. This study targeted a population of 65 computer science teachers within the division under study. Generally, there is a dearth of computer science teachers within the State, which is made manifest in each division.

To upscale and update the computer teachers in the division on what 4IR and Education 4.0 are, approval was sought and obtained from the executive office of the Computer Teachers' Association, which is the association in charge of the computer science teachers in the division to organize a-day program for the teachers. While the one-day training program, which was part of the continuous professional development objectives of the association was mandatory for the teachers, the data collection part was based on the informed consent of the teachers. Before data collection, the teachers were briefed on the purpose of the data collection, data confidentiality and privacy, and made to understand that participation in the data collection session was voluntary, and that non-participation was of no consequence. During the one-day-long program, some hours were dedicated to training the teachers on 4IR, Education 4.0, Teacher 4.0, and the skills required of computer teachers. During the training, the teachers were grouped into sessions to discuss the topics to further create awareness, and collaborative discourse and also share ideas on the topics of the session. After the end of the pairing, all the teachers came back into the main session, where final contributions, questions and after were entertained. Thereafter, the link to the Google-based questionnaire was shared on the professional platform of the teachers through which those who voluntarily volunteered took time to fill out the survey. Only 47 teachers responded to the online survey.

To collect comprehensive data in the study, a questionnaire titled "computer science teachers' Education 4.0 readiness scale" was designed and shared using Google Forms. The questionnaire was divided into two sections. The first section requested the demographic information, gender, age and years of experience, while section two contained 14 items to which the respondents responded by picking only one out of the four Likert scale responses from 1="not at all," 2="to some extent," 3="to a large extent," and 4="to a very large extent." There was no right or wrong response. The instrument underwent a rigorous process of expert validation to ensure its reliability and validity. Comprising 17 items distributed across two sections, the instrument exhibited a content validity index of 0.86, determined through the Lawshe method, and a high-reliability coefficient of 0.96, established using ordinal alpha. The study placed particular emphasis on content validity, employing the internationally recognized content validity ratio method to guarantee the instrument's appropriateness for assessing the research objectives.Recognizing the importance of using a valid and reliable instrument in research led to incorporating the Lawshe method. This method involves sharing the instrument with subject matter experts to ensure that the items in the instrument effectively align with the goals of the study, thus establishing its validity. Content validation, as advocated by Frank-Stromberg and Olsen (2004), plays a crucial role in ensuring that the instrument used for data collection accurately measures what it is intended to measure.

Table 1 presents the descriptive statistics for computer science teachers' readiness to acquire relevant skills for education in 4IR. Their responses to the statements were categorized into two groups using median values: low (1.00-2.49) and high (2.50-4.00), facilitating interpretation. Moreover, inferential statistics such as Mann-Whitney test and Kruskal-Wallis test were conducted to gain deeper insights, enabling a comprehensive assessment and interpretation of the Education 4.0 readiness of computer science teachers in the examined division.

RESULTS

RQ1. What Is Level of Computer Science Teachers' Readiness to Acquire Skills for Education in 4IR?

Table 1 indicate a high level of readiness among computer science teachers to upskill 4IR education requirements.

Table 1. Level of computer science teachers' readiness to acquire relevant skills for education in 4IR

No	Item	NA F (P [%])	SE F (P [%])	LE F (P [%])	VLE F (P [%])	M	R
1	I am prepared to embrace opportunities presented by 4IR by taking preparatory measures from this point forward.	- (0.0) 2.1	1 (2.1)	11 (23.4) 97.9	35 (74.5)	4.0	H
2	I am prepared to enhance my capabilities to align with teaching & learning methodologies of Education 4.0.	- (0.0) 2.1	1 (2.1)	10 (21.3) 97.9	36 (76.6)	4.0	H
3	I am prepared to join forward-thinking teachers who are gearing up for 4IR.	- (0.0) 4.3	2 (4.3)	14 (29.8) 93.6	30 (63.8)	4.0	H
4	I am committed to capitalizing on all possible opportunities to enhance my knowledge, ensuring that it aligns with evolving responsibilities expected of teachers in 4IR.	- (0.0) 4.3	2 (4.3)	12 (25.5) 95.7	33 (70.2)	4.0	H
5	I am prepared to acquire knowledge in modern pedagogies as demanded by 4IR.	- (0.0) 4.3	2 (4.3)	8 (17.0) 95.7	37 (78.7)	4.0	H
6	Curriculum of 21st century is heavily focused on ICT. I am not prepared for this technology-oriented role.	- (0.0) 4.3	2 (4.3)	4 (8.5) 97.5	41 (87.2)	4.0	H
7	I am prepared to acquire knowledge about IoT as part of my preparation for 4IR.	- (0.0) 0.0	- (0.0)	16 (34.0) 100	31 (66.0)	4.0	H
8	I am ready to acquire knowledge about smart campuses & classrooms in context of 4IR.	- (0.0) 4.3	2 (4.3)	16 (34.0) 95.7	29 (61.7)	4.0	H
9	I am prepared to be one of teachers of 4IR, given numerous technological innovations involved.	2 (4.2) 17.0	6 (12.8)	6 (12.8) 83.0	33 (70.2)	4.0	H
10	I am prepared to engage with EdTech services & contribute to innovative developments in education associated.	1 (2.1) 10.6	4 (8.5)	12 (25.5) 89.3	30 (63.8)	4.0	H
11	I am prepared to acquire knowledge about AI.	- (0.0) 6.4	3 (6.4)	7 (17.9) 96.6	37 (78.7)	4.0	H
12	4IR requires ongoing learning, & I am presently unprepared for lifelong learning trajectories it demands.	- (0.0) 4.3	2 (4.3)	1 (2.1) 95.7	44 (93.6)	4.0	H
13	I am prepared to initiate steps to align with transformations brought by emerging digital technologies and innovations in Education 4.0.	27 (57.4) 87.2	14 (29.8)	5 (10.6) 12.7	1 (2.1)	4.0	H
14	I am prepared to gain skills of creativity & complex problem-solving required by teachers in 4IR.	- (0.0) 2.1	1 (2.1)	13 (27.7) 97.9	33 (70.2)	4.0	H

Note. NA: Not at all; SE: Some extent; LE: Large extent; VLE: Very large extent; F: Frequency; P: percentage (%); M: Median; R: Remark; & H: High

A detailed analysis of each item reveals the following percentages and median scores: 97.9% of teachers express their preparedness to embrace the opportunities of 4IR through proactive steps (median=4.0); 97.9% are ready to upgrade their skills to align with the instructional processes of 4IR (median=4.0); 93.6% are willing to join the ranks of progressive teachers preparing for 4IR (median=4.0); 95.7% are prepared to utilize prevalent opportunities to advance their knowledge for the demands of 4IR (median=4.0); 95.7% are prepared to learn modern pedagogies expected to be prevalent in 4IR (median=4.0). Also, 97.5% of teachers express their lack of preparedness to adopt roles in ICT-oriented the 21st century curricula (median=4.0) while 100% of teachers shows reediness to become knowledgeable about IoT in reediness for 4IR (median=4.0). Additionally, the results reveal a high readiness level for smart campus/classrooms (95.7%, median=4.0), a willingness to become teachers in 4IR (83.0%, median=4.0), and a readiness to engage with EdTech services & education innovation (89.3%, median=4.0). Moreover, 96.6% of teachers express readiness to learn about AI, a key technology in 4IR (median=4.0). On the other hand, 95.7% are not prepared for the lifelong learning pathways (median=4.0), and 87.2% are not ready to initiate steps toward the transformation caused by budding technologies and educational innovations of 4IR (median=4.0). However, a significant number of the 97.9% are ready to upskill for the level of creative activities and high level problem-solving required for teachers in 4IR (median=4.0).

RQ2. Is There a Significant Statistical Difference in Level of Computer Science Teachers' Readiness to Acquire Skills for Education in 4IR on Gender?

The rank result in **Table 2** shows the mean rank and sum of rank for the two groups tested (i.e., male and female groups). Additionally, the analysis revealed that female teachers had a higher mean rank, suggesting a greater preparedness to upskill for Education 4.0, compared to their male counterparts.

Further examination of the test statistics in **Table 3** indicates the actual significance value of the test. Specifically, the statistical significance of computer science teachers' preparedness to upskill for education in 4IR, was higher in the female group compared with the male group (U=169, Z=-2.297 p=0.022).

Table 2. Mann-Whitney non-parametric equivalent of independent sample t-test (n=47)

	Gender	n	Ranks	
			Mean rank	Sum of ranks
4IR teachers	Male	25	19.76	494.00
skills readiness	Female	22	28.82	634.00

Table 3. Test statistics (grouping variable: gender)

	4IR teachers skills readiness
Mann-Whitney U	169.000
Wilcoxon W	494.000
Z	-2.297
Asymptotic sig. (2-tailed)	0.022

Table 4. Kruskal Wallis non-parametric equivalent of one-way analysis of variance (n=47)

	Experience	n	Mean rank
4IR teachers skills readiness	<5 years	3	2.00
	6-10 years	3	7.17
	11-15 years	34	28.51
	16-20 years	4	20.63
	21+	3	16.17

RQ3. Is There a Significant Statistical Difference in Level of Computer Science Teachers' Readiness to Acquire Skills for Education in 4IR on Years of Experience?

Kruskal-Wallis H test, as presented in **Table 4**, indicated a statistically significant difference in the years of experience concerning teachers' preparedness to upskill in 4IR ($\chi 2[4]=17.728$, p=0.001), with a mean rank of 4IR skills readiness of 2.00 for teachers with less than five years' experience, 7.17 for those with six-10 years' experience, 28.51 for teachers with 11-15 years' experience, 20.63 for those with 16-20 years and 16.17 for teachers with 21 years above experience (see **Table 5**).

Also, since there is a significant difference, post hoc analysis was conducted to determine where the mean difference lies in the group using pairwise comparison. **Table 6** and **Figure 3** present the statistics, as follows.

The result in **Table 6** shows that each row tests the null hypothesis that the sample 1 and sample 2 distributions are the same. Asymptotic significances (two-sided tests) are also displayed, while the level of significance is .05. The Bonferroni correction for multiple tests has adjusted the significance values.

Table 5. Independent samples Kruskal Wallis test summary

Variable	Value
n	47
Test statistic	17.728[a]
Degree of freedom	4
Asymptotic significance (2-sided test)	0.001

Note. [a]Test statistic is adjusted for ties

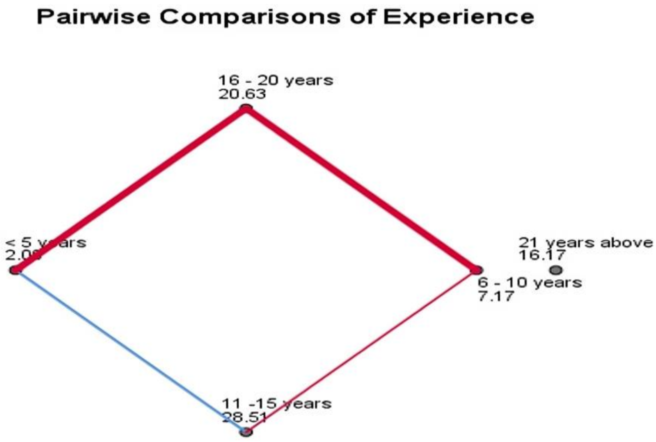

Figure 3. Pairwise comparisons of teachers' years of experience & readiness for 4IR skills (each node shows sample average rank of experience) (Source: Authors' own elaboration)

It is evident from **Figure 3** that the mean difference existed between less than five and 11-15 years of experience. The discernible variance in readiness for 4IR skills among teachers of different experience levels suggests crucial education policies and practices.

It indicates that teachers with longer tenures are more likely to possess the necessary skills to compete globally and positively influence their students. This insight underscores the need for targeted professional development initiatives aimed at fostering 4IR competencies among all teachers, irrespective of their experience. Such efforts should focus on equipping teachers with the requisite knowledge and skills to navigate emerging technologies, foster critical thinking, problem-solving abilities, and digital literacy. Additionally, it emphasizes the importance of providing

Table 6. Pairwise comparisons of teachers' years of experience & readiness for 4IR skills

Sample 1-sample 2	Test statistic	Standard error	Standard test statistic	Significance	Adjusted significance[a]
<5 years-6-10 years	-5.167	11.012	-.469	.639	1.000
<5 years-21+	-14.167	11.012	-1.286	.198	1.000
<5 years-16-20 years	-18.625	10.301	-1.808	.071	.706
<5 years-11-15 years	-26.515	8.123	-3.264	.001	.011
6-10 years-21+	-9.000	11.012	-.817	.414	1.000
6-10 years-16-20 years	-13.458	10.301	-1.307	.191	1.000
6-10 years-11-15 years	-21.348	8.123	-2.628	.009	.086
21 years above-16-20 years	4.458	10.301	.433	.665	1.000
21 years above-11-15 years	12.348	8.123	1.520	.128	1.000
16-20 years-11-15 years	7.890	7.129	1.107	.268	1.000

ongoing support to experienced teachers, ensuring they remain abreast of advancements in educational practices. Moreover, equitable access to training opportunities must be prioritized to address disparities in skill acquisition, particularly among teachers in underserved communities. Ultimately, the preparedness of teachers in imparting 4IR skills directly impacts students' readiness for the future workforce. By investing in teacher training and professional development centered on 4IR skills, educational institutions can better position students to thrive in an increasingly digitized and interconnected world, fostering global competitiveness and driving innovation on a broader scale.

DISCUSSION

The findings of the study revealed that teachers were ready to acquire relevant skills for education 4IR. Each of the 14 items for analysis in the study got a median score of 4.0, which was on the high side. This finding aligns with Corlu et al. (2014), who reported that it is not enough for teachers to have mere knowledge to raise the qualified labor power needed in the fourth industrial revolution. Teachers should enhance their existing training to align with the opportunities presented by 4IR (Ercan, 2014; Eroglu & Bektas, 2016). This observation aligns with Butler-Adam's (2018) assertion that teachers across different disciplines must comprehend the diverse factors crucial for the effective implementation of Education 4.0. This requires upskilling for effective management of and working with emerging technologies and with their colleagues. Gray (2016) argued that in the not-too-distant future, almost 35.0% of today's workforce skills would be redundant and eventually lead to new skill sets. However, Kayembe and Nel (2019) pointed out that 4IR has associated concerns involving developing and utilizing emerging technology. Hence, conscious planning is essential for managing the concerns. Given the evolving demands of 4IR, computer science teachers must enhance their training to be able to utilize emerging technologies.

The research results indicate a notable gender-based variation in teachers' preparedness to upskill for 4IR. Female teachers, as evidenced by their higher mean rank, exhibited greater readiness than their male counterparts. Additionally, statistical analysis revealed a significant difference in the readiness levels of female and male computer science teachers, with the former demonstrating a statistically significant higher preparedness to upskill 4IR. Empirical results have shown that issues around gender are also important in research of this nature because gender affects the utilization of technologies for instructional processes. However, our finding does not align with Mahdi and Dera (2013), who reported that female teachers are not as technically inclined as their male counterparts, just as Mahdi and Dera (2013), earlier found a correlational link between gender and degree of computer anxiety. Their reports seem to suggest that the level of computer anxiety affects female teachers disproportionately, leading them to be less inclined to adopt emerging technologies promptly than their male counterparts. The finding that female computer science teachers exhibit higher readiness for 4IR-related skills challenges conventional assumptions about gender and technological proficiency. The present finding contradicts previous claims suggesting that female teachers are less inclined toward technology. This connotes the need to acknowledge the dynamism of gender against the backdrop of targeted interventions, fostering an inclusive and technologically adept teaching workforce in evolving landscape of education.

Concerning years of experience, the study finds statistically significant differences in years of experience and computer science teachers' preparedness to skill up for 4IR. Experienced computer science teachers are more likely to be better positioned and prepared to embrace the requisite skills required for Education 4.0, and tackle the emerging challenges posed by 4IR. This is attributed to the belief that experienced teachers are likely to possess a more profound comprehension of traditional pedagogical approaches, demonstrate increased receptivity to adopting innovative techniques, and actively keep pace with emerging technological advancements. In contrast, their less experienced counterparts may exhibit hesitancy in adapting to the changing educational landscape influenced by 4IR.

Professional development plays an indispensable role in equipping teachers with the necessary skills (Adelana & Ishola, 2020) to effectively navigate the landscape of Education 4.0, characterized by rapid technological advancements and evolving pedagogical paradigms. Through targeted training programs, workshops, and continuous learning opportunities, teachers can cultivate competencies in digital literacy, adaptive teaching methodologies, and the integration of emerging technologies such as AI, virtual reality, and data analytics into their instructional practices. By embracing professional development initiatives, teachers can enhance their ability to engage students in personalized and immersive learning experiences, foster critical thinking, creativity, and collaboration, and ultimately prepare them for success in a rapidly evolving, digitally-driven society.

CONCLUSIONS & RECOMMENDATIONS

The findings of this study underscore the urgency and need for computer science teachers to be adequately prepared for the opportunities, as well as the challenges presented by Education 4.0 in 4IR.

The consistently high median score of 4.0 across all the 14 items analyzed in this study strongly shows computer science teachers' preparedness to acquire the necessary skills essential for navigating 4IR. Prior research emphasizes that mere knowledge is insufficient because teachers need to and must actively enhance their training to qualify for effectively key into what Education 4.0 has to offer as well as being able to effectively instill necessary skills in their students. This finding further shows the need for continuous professional development programs, especially those capitalizing on the opportunities proposed by Education 4.0 in 4IR. This aligns with the advocation that across disciplines, teachers need to work together for the successful implementation of Education 4.0, for the betterment of their students.

Contrary to previous assertions, the study's findings indicate that female teachers also exhibit greater preparedness to upskill for Education 4.0 in 4IR, just as found among their male counterparts. These results challenge prior reports (Mahdi & Dera, 2013), which suggested that female teachers are less technically inclined than their male counterparts. The finding from this study further emphasizes the imperativeness of paying attention to gender dynamics in technology integration into instructional processes.

In essence, jettisoning the potential of female teachers in embracing emerging technologies is likely to result in the loss of opportunities for educational advancements in 4IR, resulting in gender bias in academia. Hence, the technological preparedness of male and female teachers must be recognized and accorded due diligence to foster inclusive progress in computer science education in 4IR.

Furthermore, the finding of this study identifies a significant correlation between teachers' years of experience and readiness to upskill for 4IR. This underscores the relevance of giving due diligence to years of experience when addressing computer science teachers' readiness for the challenges posed by education in 4IR. The differences in mean ranks across various years of experience emphasize the dynamic nature of skill acquisition over teachers' professional trajectories. This finding is important for developing an effective professional development program that addresses computer science teachers' specific needs concerning their years in the teaching profession. In other words, stakeholders in education, educational institutions, policymakers, professional associations, and employers can leverage these insights in designing effectively relevant professional development initiatives that bridge the gap in readiness for Education 4.0. The call for specifically tailored training programs underpins the relevance of actionable measures needed to be taken to ensure a technologically competent, and forward-looking teaching workforce.

Finally, this study contributes valuable insights into the relationship between computer science teachers' gender, years of experience, and preparedness to acquire pertinent skills for Education 4.0 and their ability to confront the challenges intrinsic to education in 4IR. As education continues to evolve in the face of rapid technological advancements, paying critical and urgent attention to these disparities becomes important to create a learning environment that fosters students' acquisition of required skills for the life and jobs of 4IR.

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