Science teachers' beliefs about the impact of 4IR on their classroom practices

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Abstract. Embracing the Fourth Industrial Revolution (4IR) in the education system has become mandatory considering the COVID-19 pandemic. Because this is a 'revolution' many science teachers have been caught off guard and may harbour mixed feelings regarding their roles and what the future has in store. The current qualitative study sought to establish newly qualified science teachers' beliefs about their roles in science classrooms where 4IR is embraced. An online questionnaire was administered to 60 participants to establish their preparedness and competencies, resource availability, and future professional prospects. Data was subjected to content analysis and three themes emerged: 1. Teachers believed that the government and the Department of Basic Education's stance to embrace 4IR is a vehicle that promotes unequal education opportunities for science learners. 2. Most of the science teachers believed they were not technologically prepared to embrace 4IR tools such as Artificial Intelligence (AI), coding and robotics. 3. The science teachers believed that too much utilisation of technology in a science classroom demeans the actual teaching and learning of scientific concepts. The findings contribute towards the call to change the status quo on the disparities between urban, rural, township and suburban schools in terms of resource distribution and teacher professional development.

Key words: Classroom practices, science teacher beliefs, 4IR.

1 Introduction

Because of the current global pandemic many countries have embraced 4IR in their education system and South Africa is part of the change. As such 4IR affects every human facet let alone science teaching and learning [1]. It has also been found that sometimes there is a mismatch between teachers' beliefs about the affordances of technology and the actual practices in the classrooms due to contextual factors. Because this is a 'revolution' many science teachers have been caught off guard and they harbour mixed feelings regarding their roles and what the future has in store for them.

1.1. Problem statement

The onset of the COVID-19 pandemic has necessitated that schools embark on online or remote teaching and learning mode. Such a scenario required teachers' competencies in technology use though such a call has been made previously regarding the need for teachers to be equipped with digital skills. It is however inevitable to establish teachers' preparedness because the success of an

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innovation in the classroom is dependent on the teachers' willingness and ability to implement it. Researchers have indicated that a crucial factor for successful technology integration into the classroom is the teacher [2]. On the other hand, teachers' beliefs are a revelation of their thought processes which are more influential than the teachers' knowledge when it comes to lesson planning, decision-making and ultimately on how they teach [3]. Hence teachers' beliefs about their role should help to shed light on how they make technology integration decisions [4].

1.2. Purpose of study

The study was premised on the reality that embracing 4IR tools in the science classroom is inevitable, but also on the knowledge that the way in which teachers perceive an innovation impacts on the successes of its implementation. It is against this backdrop that the current study sought to establish newly qualified science teachers' perspectives on their roles due to the call to embrace 4IR tools in their classrooms. The study was guided by the research question: What are science teachers' beliefs about their roles in science classrooms where 4IR is embraced?

2. Literature review

Teaching should develop learners for survival in an environment for which Reaves coined the term VUCA: "volatility, uncertainty, complexity, ambiguity" [5] (p. 1). Researchers acknowledge the importance of developing learners to be flexible, adaptable, creative and innovative [6] [7] which are some of the 21st-century skills. To achieve such skills science learning should embrace 4IR, which prepares learners for the unforeseen future [8].

2.1. 4IR as the conceptual framework: The need to embrace 4IR in the science classroom

4IR has been defined as the fusion of technologies which blurs the lines between the physical, digital, and biological worlds [9]. 4IR has been found to provide and cause significant influence on instructional and learning opportunities and education policies [10]. As such, the future prospects afforded by 4IR motivate teachers and researchers to search for more knowledge and skills to prepare science learners [11]. During 4IR teachers co-teach, team teach and collaborate with others rather than teach in isolation [12]. Teaching should involve 4IR technologies, such as mobile and augmented reality (AR) and virtual reality (VR) and 5G [5].

2.2. Science teacher beliefs about technology integration

From a philosophical perspective, beliefs are defined as "psychologically held understandings, premises, or propositions about the world that are felt to be true" [13] (p.103). From an educational standpoint, beliefs are one's convictions and opinions about teaching and learning [14]. Whilst beliefs are considered to be persistent, they however change with experience [15]. Studies have shown that teachers' beliefs are consistent with their classroom practices [16] [17]. This said, science teachers' beliefs about technology integration is vital as this will have implications on how they embrace 4IR in their classrooms [18].

3 Methodology

Located within the interpretive paradigm [19] which enabled the researcher to make sense of the science teachers' beliefs, the study adopted a qualitative case study research design. A qualitative study allows the assessment of the lived experiences of participants [20]. A case study allowed the exploration of a phenomenon [21] and in this case the teachers' beliefs about how their practices could be impacted in science classrooms where 4IR is embraced. The case in this study was newly qualified science teachers who had just completed a four-year teacher professional development programme at a University in South Africa. The unit of analysis, therefore, was the science teachers' beliefs about their levels of preparedness in terms of competencies, resource availability and management, and future

professional prospects in order to examine the teachers' beliefs about their roles in science classrooms where 4IR is embraced.

Using purposive sampling technique [22] 60 science teachers were selected as participants. The participants were ideal considering their relative young age which is 'the digital age' group [23]. An online questionnaire designed by the researcher was administered to the teachers who had just qualified to teach science. The questionnaire specifically sought science teachers' levels of preparedness in terms of competencies, resource availability and management, and future professional prospects. Data was analysed using content analysis [24] wherein codes and categories were identified leading to relational analysis. Through content analysis the researcher carefully reviewed the teachers' responses to identify pertinent information from non-pertinent information and to make sure the information was organised into categories related to the research questions [25].

4 Research findings

The findings are presented under three themes which depict the science teachers' beliefs about their roles in classrooms that embrace 4IR. Their beliefs were centred on issue of 4IR promotion of unequal education opportunities (73%); their lack of confidence and fear of the unknown (81%); and the teachers questioning the efficacy of 4IR in making science concepts comprehensible to learners (57%).

4.1. Theme 1: *The majority of teachers (73%) believed that the government and the Department of Basic Education's stance in embracing 4IR is a vehicle that promotes unequal education opportunities for science learners.* The teachers' argument was that whilst it is a welcome development, there has not been parity in resource distribution in schools because learners come from diverse socioeconomic backgrounds. Their point was that those from disadvantaged backgrounds even struggled with acquisition of simple calculators, which means that the acquisition of electronic gadgets for use in the classroom learning could even be out of reach for many. To show the gravity of the matter, one of the science teachers said, "Will the government and the Department of Basic Education provide for the poor orphan to acquire a laptop yet struggling to get the next meal?"

The teachers' beliefs are that whilst 4IR integration in the science classrooms may be beneficial to the elite (referring to learners coming from advantaged backgrounds and schools), this may not be the case for learners from township and rural backgrounds. The majority of the teachers painted a gloomy picture on the possibilities of equal education opportunities for science learners as encapsulated in what one science teacher said,

> Technology integration does not only require the acquisition of electronic gadgets but other services such as availability of internet connectivity, availability of electricity, and let alone skilled manpower to assist teachers and learners in case of technology failure in the science classrooms.

The teachers pointed out that because 4IR changes the frame of science education, if a school is not technically advanced then learners will be left behind, which is likely to increase the disparities in schools in different school environments. Some of the science teachers strongly believed that the integration of 4IR will exacerbate the inequality in the South African education system which they blamed on the irregular provision of resources in schools, primarily caused by corruption and lack of financial assistance to accommodate all the needs of the schools.

4.2. Theme 2: *Most of the science teachers (81%) showed lack of confidence as they believed they were not technologically prepared to embrace 4IR tools such as AI, coding and robotics.* As such, they expressed fears and insecurities when it comes to their competencies to deliver

technology led classroom teaching and learning of science. To show the teachers' fears of the unknown, the following are some of the responses.

Teacher 1: What if the robot replaces me and I'm left without a job?

Teachers 2: If learning can happen over a video call streaming, one teacher can teach as many as 100 learners in one session meaning job opportunities for teachers will be diminished because of 4IR.

Teacher 3: I fear that those robots may know more than me and the learners would enjoy the time with the robot more than with me as the human teacher.

A point to note is that whilst some science teachers welcomed and embraced 4IR in the education system, others were hesitant as the issue of job securities came into play. They feared machines would replace them in the classroom as one teacher said, "Because robots can be programmed to teach relevant content without any errors, myself on the other hand sometimes make mistakes when explaining some science concepts". The teachers believed they were not well equipped to embrace 4IR tools in their science classrooms as attested by the following excerpt:

Teacher: I lack the digital knowledge and skills to ensure innovative and creative science classrooms using technology.

The teachers believed they did not receive adequate training during their teacher development programmes at university because of various constraints which included the lack of facilities, and the nature of the curriculum which did not make 4IR integration mandatory. The teachers' bone of contention is that how then are they expected to implement an innovation without being equipped.

4.3. Theme 3: *The science teachers (57%) believed that too much utilisation of technology in a science classroom will demean the actual teaching and learning of scientific concepts.*
In this case the teachers questioned the effectiveness of technology in providing meaningful learning of science.

Some of the teachers welcomed the benefits of being relieved from working extra hours with the introduction of artificial intelligence (AI). In this way they considered that learners will be more involved in technology and information will be shared easily. As such, they believed the teaching and learning process will be done speedily. To this one of the teachers said, "My fear on the 4IR is that most teachers will abuse the use of technology, they will just relax with the hope that technology will do the work". The teachers argued that machines do not provide prompt responses to learners regarding issues arising in the science classroom.

This belief is shared by many who argued that the human input is needed in the actual teaching and learning since teaching is a social human endeavor, where interaction is inevitable. They cautioned other science teachers to desist from renegading their duties to technology but rather utilise technology to enhance the teachers' efforts. The teachers argued that learners need both worlds, advanced technologies provided by robots, and the irreplaceable social/emotional quality of humans.

5 Discussion

Teachers believed that the government and the Department of Basic Education's stance to embrace 4IR is a vehicle that promotes unequal education opportunities for science learners. The lack of pedagogical adaptation, and the poor teacher development were also found to be challenges that

schools and societies face due to 4IR in a study by Kayembe and Nel [26]. The science teachers believed that they were not technologically prepared to embrace 4IR tools such as AI, coding and robotics hence they lacked confidence. Because teachers are the agents of change in the 4IR, the way in which they perceive technology can be either developmental or destructive when it comes to developing learners' 21st Century skills [27]. Thus said, science teachers should be developed so that they can be competent to integrate 4IR in their classrooms.

The science teachers questioned the efficacy of 4IR tools if used alone in making science concepts more comprehensible to the learners. Such beliefs bring in the role of pedagogy of care which is pertinent particularly considering the current COVID-19 pandemic, that machines cannot provide. The teachers' beliefs resonate with the call made in the previous study that teachers need to demonstrate acts of caring as ultimate goals of teaching [28]. The teachers in the current study believed that too much utilisation of technology in a science classroom would demean the actual teaching and learning of scientific concepts. In a previous study [10] pre-service science teachers were found to also display very low perceptions with regards to the human element required between the interactions of teachers and learners as they believed that robots and artificial intelligence only execute the input data but do not have emotional skills to understand attitudes and values.

6 Conclusion and recommendations

Whilst some of the science teachers indicated in their responses that they were not ready for 4IR as an innovation because of poor digital skills, unavailability of resources and insecurities, there is need to move with the times and adopt the innovation. A point to note from the findings is that nothing points to the teachers' negative attitude towards the integration of 4IR per se as an innovation but instead their beliefs emanated from the issues regarding its implementation. Based on the teachers' beliefs, the study suggests that if schools, teachers and learners are equipped with the necessary resources (e.g. electronic gadgets, necessary facilities, connectivity), and competencies, embracing 4IR in the science classrooms would be well received. The findings suggest the need to change the status quo on the disparities between urban and rural, as well as township and suburban schools in terms of resource distribution. Teacher professional development programmes are needed for continued technological knowledge and skills development of science teachers.

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