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Strategies for Encouraging and Supporting Implementation of the Fourth Industrial Revolution in Rural Public Primary Schools

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ABSTRACT

Incorporating Fourth Industrial Revolution (4IR) technologies into rural primary schools presents special challenges and opportunities, notably depending on socio-economic background and the involvement of female principals. This paper explores what female principals in rural public primary schools in South Africa find difficult in these scenarios, and aims to identify best practice in assisting their leadership through technological transition. It responds to the specific needs of these executives in how to make sense of technological change within a safe and educational setting. Emotional intelligence, career preparation, and community engagement are highlighted by the research as critical to successful 4IR implementation. By qualitative means which include interviews with 20 female principals from Mpumalanga in South Africa and document analysis, key approaches are identified, including partnership with local organisations, needs assessments, and promotion of cutting-edge teaching methods. The results indicate the need for a multi-pronged strategy involving both resource acquisition and capacity building to close the digital gap and equip students for the future. This study, through promoting partnership and continual education, offers valuable knowledge on how female school leaders can be empowered to use 4IR technologies in their schools.

Keywords: *Fourth Industrial Revolution; technology; rural public primary school; female principals; capacity building; professional development; community engagement*

INTRODUCTION

Implementation of 4IR technologies in rural primary schools is an exciting but challenging education revolution, especially in South Africa. Women in school leadership, who traditionally do not have representation in educational leadership roles, are disproportionately challenged by how to incorporate technological innovation into a patriarchal and resource-limited society. Globally and nationally, 4IR deployment in rural public primary schools is blocked by a complex set of educational problems. Globally, women still are not very often in leadership roles which directly affects the availability of 4IR technology. Stigmatization and mentorship stall female leaders in their ability to bring technological change (Gause, 2022). Most countries have poor technologies adoption infrastructure, without reliable Internet access, the quality equipment, and teacher training programmes for proper implementation (Hossain, 2023; Kayembe & Nel, 2019). Educational modernisation is imperative, because traditional approaches continue to shape education, and students are not ready for a tech career.

Rural schools in South Africa are limited in the amount of funds that can be invested into technology and education to meet the needs of the learners, which makes the digital divide between rural and urban institutions more acute (Cwala, 2022; Mokate, 2023). Lack of teachers' training programmes exacerbates the problem, and most educators don't even know how to teach the skills such as coding and data literacy (Nkosi & Moyo, 2024). Moreover, the current patriarchal architecture of the education system limits the capacity of female principals to lead and hinders their engagement in campaigning for technological integration and a just education (Ferritto, 2024). Female administrators struggle to influence parents and communities about the value of technology in education, and 4IR projects fail (Mokate, 2023). At the national and international levels, gender

differences, financial restrictions, curriculum and social dynamics play major roles in the adoption of 4IR in rural public primary schools. These problems need to be solved to ensure an inclusive, egalitarian education system that positions children for the future.

Responding to these problems, scientists have suggested formal, global and even national-level interventions. In the rest of the world, gender parity in leadership in education is strongly embraced. Scholars call for mentorship and training to enable female executives to take new technologies to the market (Gause, 2022). Further, experts recommend higher investments in education infrastructure for better Internet connections and advanced hardware along with effective teacher-training courses on how to use technologies (Hossain, 2023; Kayembe & Nel, 2019). This includes curricula modernisation; and schools are also invited to embrace project-based learning models that are responsive to the needs of the digital economy.

Nationally in South Africa, researchers call for government policies that allow rural schools sufficient funding to buy basic technology (Cwala, 2022; Mokate, 2023). They also mention that targeted professional development is required to teach teachers key skills like coding and data literacy (Nkosi & Moyo, 2024). The solution is to break down the patriarchal barriers of the education system to enable female principals to advocate for technology integration and equitable education (Ferritto, 2024). And lastly, creating strong local connections with communication can drive interest in technology programmes among parents and local stakeholders (Mokate, 2023).

The paper is a response to the research question of how female school principals in rural public primary schools experience and adopt 4IR technologies, their leadership and their efforts to enable technological co-creation. This research aims to provide a description of how female principals can effectively promote adoption of 4IR technology in their school through gender equality and inclusive leadership. This research is of relevance to inform policymakers and stakeholders in education on the role that women leaders play in bringing technological transformation, thus advancing the agenda of gender equality in education and calling for structural change to enable female leadership in rural education. In shedding light on these principals' experiences, the research intends to offer guidance that will enable the digital divide to be closed, and future learners empowered.

THEORETICAL FRAMEWORK

Critical feminist theory is the framework chosen to study women school leaders who are using 4IR technologies in rural public primary schools. This theory emphasises the importance of gender oppression and the need to investigate the specific trajectories that female leaders face in these settings as they deal with patriarchal hierarchies and social expectations that do not always serve them well (Ferritto, 2024). Through the emphasis on experiential epistemology, critical feminist theory provides opportunities for female principals to voice their own stories and counter-stories to illuminate the challenges they face, to advocate for gender equality and inclusion in leadership. The theory also emphasises the interrelation of gender, geography and technology, and what those intersect with when it comes to leadership roles and experiences among women in rural education (Fuller, 2021).

In its tradition, critical feminist theory emerged in the first half of the 20th century to push back against patriarchy and on behalf of women (Mullinax et al., 2018). Critical feminist theory is often mistaken as disunity on principles and subjective values, but the emphasis on recognising oppressed voices is just as important to what we can do about female principals' experience (Allen, 2023). By bringing these voices into the centre, critical feminist theory shows how gendered hierarchies affect female teachers in classrooms. It also calls for historical and contextualisation of policies related to women in leadership positions with a focus on systemic challenges that limit their capacity to apply 4IR technologies (Pasque & Nicholson, 2023). Finally, when we apply critical

feminist theory to the case of rural public primary school female principals, not only can we better understand their struggles, but we can thereby drive radical change towards a more equal education.

Strategies for female principals in rural primary schools to leverage 4IR opportunities

Female principals are advised to focus on learning empathy and listening to learn more about their teachers' and students' needs, since they are the foundation for successful deployment of 4IR technologies (Mirra, 2018). Such an emphasis on emotional intelligence has the backing of researchers from Europe (Mayer, 2019), Malaysia (Daud et al, 2021) and South Africa (Conley-Temgire, 2023; Hossain, 2023). For staff to become invested in 4IR projects, female principals need to foster imaginative teamwork and authentic participation to be adaptable in a rapidly evolving education environment (Oke & Fernandes, 2020). Female leaders who invest in active listening and empathy can support teachers and develop a vibrant school culture in response to the needs of a 21st century learning environment.

Women principals, in addition to emotional intelligence, should have their own 4IR-Intelligence, namely, contextual, emotional, inspired, and physical intelligence, so that they can best lead their schools into the 4IR era (Moloko, 2021). Professional development involves mentorship from educators who are experienced and who have successfully utilised 4IR technologies (Mhlanga, 2024; Motebele, 2020). Prioritising teacher training would guarantee teachers with the right tools to bring technology into the classroom (Awodiji & Naicker, 2023; Cwala, 2022). Working with non-profits and government organisations can also help in bringing resources to implement technology in the schools (Ally & Wark, 2020). With an attitude of lifelong learning, culture of innovation, and strategic partnerships, female principals can meet the demands of the evolving technology environment and provide every student with a future-focused education.

Interventions for promoting 4IR implementation in rural schools

Rural schools have opportunity as well as challenges in the 4IR (Jindala, & Sindhu, 2022; Yende, 2021). These are the intervention measures, which describe the critical elements to implement the 4IR successfully.

Evaluation of requirements and inventory of available resources

Female school leaders must conduct a needs assessment to assess the exact challenges and opportunities of the 4IR in school (Letuma, 2023, Ndzandzeka, 2021; Naidoo, 2022). The current infrastructure, Internet access, accessibility of devices, and teachers' competence with the integration of technology and students' digital literacy abilities should be evaluated (Fominykh, Shikhova, Soule, Perifanou & Zhukova, 2021). They must evaluate the existing investments, such as technology, software licenses, and partnerships with local organisations. This enables the realisation of present value and the identification of shortcomings. Through data-led decisions and a needs-based survey, female school administrators can customise their 4IR implementation plans to fill in gaps and prepare students for the digital world.

Improving infrastructure and procuring advanced technology

The US-African comparative review paper underscores that funding through grants, government initiatives, and partnerships with the private sector is needed to bridge the digital divide and support critical infrastructure (Adeleye et al., 2024; Raji et al., 2024). It is a strategy echoed by other researchers who have also proposed that such support will help to provide the technologies needed such as gadgets, broadband and education software (Gracias et al, 2023). Women school administrators are also urged to use cost-effective or open-source technology to optimise

resources. Also essential are government investments to upgrade the infrastructure of rural schools, which means modern classrooms and safe energy supply (Barasa, 2021; Scalzo, 2023; Wang & Wang, 2023). Partnerships with government and commercial institutions are also key to getting the funding and resources to implement technological solutions in rural education (Sachs et al, 2019; Union, 2020). The digital divide can be solved only if female school heads develop a holistic approach to raise more funds, look at the affordability of solutions, and develop public-private partnerships to prepare rural schools for the realities of a 4IR education.

Enhancing the proficiency of teachers

It is recommended by scholars that professional development initiatives should be funded in order to equip teachers with competencies to implement 4IR technologies into their classrooms, for example, in Turkey (Sancar et al, 2021; Van Wyk, 2022), Nigeria (Awodiji & Naicker, 2023) and South Africa (Kadenge, 2022; Krishnannair et al, 2022; Letuma, 2023; Mhlongo et al, 2023; Naidoo, 2022; Sasere & Makhasane, 2023). Such training could be related to technology usage, adherence to project-based learning practices, and data visualisation for making informed decision-making (Naidoo, 2022). Secondly, teachers can create a learning community to share the 4IR ideas and practices (Ally & Wark, 2020; Chigbu et al., 2023). Remaining informed and guided by school leaders, too, is needed to make teachers respond to the new realities of education in places like Qatar (Abulibdeh et al., 2024), Indonesia (Puspitasari et al., 2023), and South Africa (Naidoo & Potokri, 2021). Female school leaders can train, collaborate, and support teachers to become the heroes of the 4IR, enabling them to change classrooms into exciting spaces where students are engaged.

Cultivating an innovative culture

Women school leaders can advocate for an attitude of innovation, risk and taking risks, and learning from failure as a learning experience for themselves, teachers and students (Jansen, & Mokhele, 2023). Female school leaders from rural districts can also share best practices on how to apply the 4IR by sharing knowledge among schools (Ally & Wark, 2020; Letuma, 2023; Nkambule, 2023; Naidoo & Potokri, 2021). Researchers in the UK, Australia and South Africa advise education authorities to develop specific interventions to make 4IR technology and resources accessible equally in both urban and rural schools (Gordon & Thompson, 2024; Scalzo, 2023). Leaders in schools can make partnership connections with non-profit organisations and government departments to support and finance remote schools (Jansen, & Mokhele, 2023). By creating the growth mindset and all-level collaboration, rural female school leaders can cross the digital gap, transforming these schools into oases of creativity and empowerment in the 4IR era.

METHODOLOGY

The study positioned itself within the interpretivist approach and employed qualitative research to describe the varied lives of women principals in rural primary schools in South Africa. Through hermeneutical interpretivism and phenomenology, the research also valued subjective interpretations, which derived from identity and culture, in the researchers' descriptions of social experiences (Sileyew, 2019; Rosenthal, 2018). Axiology, or the values theory of research, emphasised the personal nature of the research, since one of the researchers' accounts of her experience of social problems as a female principal was drawn from her personal experience. Such an interpretivist model was ideal for capturing subtle aspects of female principals' 4IR experiences (Creswell & Creswell, 2018). The epistemology was emic in nature and centred on participants helping to understand their world (Nieuwenhuis, 2016). The study sought to understand the practices of these principals applying 4IR practices in their schools.

Interviews and document analysis helped the researchers to observe the nuance of their experiences, which were critical to how educational leaders see their function considering new technologies (Poth, 2018). The use of phenomenological techniques such as semi-structured interviews made it easier to unearth rich stories about female principals' personal struggles and achievements. This thorough study provides policymakers with some important findings and explains how these leaders can be better supported in their endeavours so that they can make progress in rural education in South Africa.

Data analysis was performed with the hermeneutic circle method which includes reading and thinking about data in a circle to discover new information. This is done by reading the whole text and interrogating each sentence to iron out contradictions and derive meaning (Grondin, 2015). The authors sifted through interview transcripts and document reviews to picture statements that they believed were relevant to the research questions (Dangal, 2021). The researchers organised relevant information into concepts, and organised these into meaning units describing aspects of the phenomenon as participants understood them (Dangal, 2021). A constant pursuit of other ways of understanding permitted a closer investigation of how female school leaders encountered and interpreted the phenomenon (Dangal, 2021). Eventually, an all-encompassing description resulted from this process, which combined multiple meanings discovered during the study (Dangal, 2021). The researchers used convenience sampling to enlist 20 female headteachers in rural public primary schools in Mpumalanga province who ran coding and robotics classes. This non-probability design was selected because it was accessible but admitted to randomisation biases (Simkus, 2022).

Qualitative research needs to be trusted if it is to capture participants' experience. Lincoln & Guba's (1985) criteria of credibility, transferability, reliability and confirmability were applied. Credibility requires existing data collection methods like audio recordings of interviews and member checking interpretations (Bertram & Christiansen, 2014). Transferability requires more context so that readers could determine whether results could be applicable to their own circumstances (Bertram & Christiansen, 2014). Dependability is about recording the conduct of research so that similar trials could be performed, and confirmability is about keeping things objective by grounding findings in participants' experience (Lincoln & Guba, 1985). To give them more credence, the interview transcripts were obtained from good sources which include audio recordings and standard questioning practices (Bertram & Christiansen, 2014). In addition, providing detailed background on the study context will help readers place findings into context. Documentation of the study process allowed subsequent researchers to repeat or cross-reference results from other studies.

Research must be ethical to maintain participant dignity and ensure obligations to subjects and to scientific community (Mirza et al., 2023). When researchers treat sensitive issues in line with ethical protocols, trust is developed and research integrity is maintained (Israel & Hay, 2006). Ethical issues include informed consent, confidentiality and anonymity, and cultural tolerance (Creswell & Creswell, 2018). Following this ethos, the approval of university ethics committee and the Mpumalanga Department of Education was sought. Participants completed privacy-ensuring consent forms and were advised that they could withdraw their consent at any time (Parveen & Showkat, 2017). The researchers communicated with participants regarding the progress of the study and gave them copies of their responses once the data were collected (Mirza et al, 2023).

RESULTS

Applying holistic and inclusive approach to 4IR implementation

Female leaders use the we-sense strategy to foster knowledge sharing within the school community, fostering mutual accountability and fostering an adaptive atmosphere. Participant one asserted:

> *"Principals must involve all stakeholders or school community members in the school's planning so that they all own whatever is agreed upon"* (L283-L285).

Community outreach and education can enhance 4IR technologies awareness, foster community trust and investment, and enhance the success and sustainability of 4IR programmes. Participant sixteen affirmed:

> *"Community engagement and education about the importance of 4IR can increase community buy in and support for 4IR programmes"* (L98-L99).

Parent-teacher conferences highlight the impact of 4IR technologies on children's futures and encourage their involvement in incorporating 4IR into schools to better prepare them for an automated world. Participant eighteen elucidated:

> *"When we are in meetings with parents, we do talk about the importance of 4IR in the lives of the learners"* (L165-L166).

Inclusive school cultures foster empathy, purpose, and professional learning opportunities, preparing learners for global citizenship and empowering stakeholders. Participant seven elucidated:

> *"Establishing inclusive decision-making processes involving diverse stakeholders and providing professional development opportunities for teachers, fostering a culture of diversity, equity, and inclusion"* (L21-L23).

The participants facilitated the adoption of 4IR by teachers and staff through training, workshops, and peer coaching, enhancing their pedagogical and administrative effectiveness in learning, teaching, and working with 4IR technologies. Participant three recounted:

> *"When it comes to our teachers and support staff, we have taken a multi-pronged approach to driving 4IR engagement and usage"* (L284-L286).

Rural primary schools are fostering a community learning space that promotes equal technology use, basic skills, and demystifies the digital world, reducing the mythical digital divide. Participant four explained:

> *"Additionally, we established a computer centre at the school, which has been accessible to all members of the school community including learners, staff, and parents."* (L111-L116).

The initiative aimed to foster a digitally literate and empowered school community by promoting 4IR technologies, computer lessons, and software sharing among participants and teachers. Participant eleven narrated:

> *"While we have not yet reached the point where the whole school community is fully involved due to insufficient resources, we have made progress in certain areas. All learners have computer lessons that are included in the school timetable, with each grade attending for one hour per week to use educational programmes like Matific and Reading Eggs."* (L48-L54).

The participants believe that the solution to the digital divide lies in teacher training and parental engagement, empowering children to utilise technology and the Internet for learning. Participant thirteen affirmed:

> *"To ensure equity and inclusivity, we provide comprehensive training for teachers, support learners from disadvantaged backgrounds with access to devices and internet connectivity and engage parents and the broader community through workshops and communication"* (L86-L89).

The analysis of the documents found that female principals were using the we-sense approach to encourage knowledge sharing across their schools and involved stakeholders in the planning process to foster shared responsibility. Parent-teacher conferences also offered the opportunity to discuss the importance of 4IR in preparing students for the future. The incorporation of technology, like laptops and interactive boards, was mentioned to enhance administrative productivity and foster learning. Meeting minutes, school improvement plan, meeting attendance registers, and school reports were some of the documents viewed. Laptops and interactive boards were also envisioned.

Balanced Perspective

Digital skills classes for Grades R-7 improve computer literacy and digital skills for life and the 4IR, preparing learners for future competitiveness. Participant one asserted:

> " *What we managed to do is to give all learners access to computer literacy classes, which cater for Grade R to Grade 7 learners in the school. I think by doing so, we are preparing them for the 4IR" (L133-L135).*

The participants also reported the necessity to incorporate 4IR skills into curricula, foster growth mindset in staff, and provide learning opportunities for better digital navigation. Participant three noted:

> *"Integrating 4IR concepts and tools into the curriculum is crucial for ensuring our learners are equipped with the right skills. And as a leader, it is important that I model continuous learning and professional growth"* (L139-L144).

Women heads in rural primary schools are encouraged to adopt 4IR for digitalisation, as it improves learning outcomes, prepares learners for industry, and increases community visibility. Participant four explicated:

> *"My advice to rural women leaders driving 4IR in schools: take action, it is easy, manageable and simplifies work."* (L251-L254).

Female managers foster buy-in from all parties by working with affected parties, including parents, and planning well, ensuring initiatives are delivered as planned, ultimately focusing on proceed. Participant six elucidated:

> "*The advice I would give to other female leaders is to involve all relevant stakeholders and inform the parents about the implementation of 4IR. The issue of proper planning is key. There must be a programme in place that will be distributed to all SMT members"* (L83-L86).

The schools have actively engaged parents in continuous educational improvement, embracing the 4IR and integrating technology, particularly using cellphones by learners and staff. Participant fifteen recounted:

> *"The parents were excited about this programme, and we discussed school cellphone use, suggesting learners have them on certain days. The parents were very supportive of this initiative"* (L410-L415).

Participants prepare educators and staff for 4IR technologies, enhancing skills to effectively use AI and enhance human attributes in the new work world. Participant fourteen affirmed:

> *"Deliver instruction and assistance to educators and personnel to ensure they possess the essential expertise and understanding to proficiently utilise and uphold 4IR technology"* (L132-L134).

The timetables of the schools were then used to confirm the data received via the semi-structured interviews emphasising the digital incorporated skills classes for grade R-7. Meeting minutes and meeting attendance registers were used as evidence of engaged parents. Workshops and attendance lists were scrutinised for checking teacher training and support.

Patience and Persistence

Female principals can utilise 4IR to enhance advocacy, stakeholder relations, resource acquisition, and problem-solving by focusing on teaching and pedagogy, ultimately improving learning and learner performance outcomes. Participant two noted*:*

> *"By embracing this multifaceted approach, you can navigate the challenges, build a resilient and innovative school community, and ultimately realise the transformative potential of the 4IR in education"* (L286-L290).

Adversity is a challenge, but perseverance, dedication, breaking barriers, and the design of innovative solutions can open doors of opportunity for all, including women. Participant thirteen asserted:

> *"I advise other women leaders to remain resilient and visionary"* (L133).

Integrating teaching in the 4IR empowers learners to become designers, continuously improving their skills and teaching new generations. Participant five affirmed:

> *"By implementing 4IR in our institutions, we are making a bright future for our learners. This should be the driving force behind our efforts"* (L255-L257).

The female school leaders utilised faculty expertise and storytelling to educate colleagues about 4IR's potential to transform teaching and learning, fostering innovation, resource sharing, and digital literacy. Participant three stated:

> *"We have also established 4IR champion roles, where we have identified tech-savvy teachers and staff members to serve as peer mentors and advocates. These individuals help spread awareness, share best practices, and provide hands-on assistance to their colleagues"* (L296-L299).

A participant suggested that teachers should approach 4IR integration with openness, patience, and empathy, despite facing pushback from parents and the community, to facilitate gradual and empathetic change. Participant eleven asserted:

> *"I advise them to be open-minded about 4IR and to recognise that it may take time for the community, especially the parents, to accept and embrace the changes that come with it"* (L152-L154).

The participants also reported that passionately believing in their vision and never giving up can overcome stress and cynics, even surpassing plans or hope, provided they silence the noise. Participant ten stated:

> *"To achieve success, it is essential to focus on one's goals and not let others pull them down"* (L81-L82).

Incremental innovation, which involves gradually introducing new technologies and allowing teachers to adjust, helps prevent confusion and promotes a shift-culture that adapts to modern life. Participant one explicated:

> *"Rather than implementing changes all at once, you introduce new technologies and methods gradually, allowing staff to adjust at their own pace and reducing the overwhelming feeling that can come with significant changes"* (L123-L126).

The participants emphasised that female principals must embrace every defeat, failure, and error, as only by accepting their shortcomings can they become whole, wise, and successful. Participant twelve recounted:

> " *What is mostly needed is determination, focus, and do not be afraid of failure, because if you do not fail, you will not learn" (L127-L129).*

A letter to the department of education requesting assistance on schools' computers upgrade was seen as well as request letters written to possible donors were also viewed to corroborate the data gathered via the semi-structured interviews.

Addressing Vandalism and Theft

The female school leaders advocate for the installation of security cameras to ensure learner safety, create a secure learning environment, deter potential threats, and promote productivity. Participant ten conveyed:

> *"Implementing security cameras or alternative security systems is recommended"* (L56-L57).

Establishing a community liaison fosters collective stewardship, shared accountability, and a united guardian against theft and burglary, demonstrating the potency of a robust community spirit. Participant one narrated:

> *"We have a partnership with the community to safeguard the school against theft and burglary, protecting the available resources we have because we do not have enough funds to hire a professional security company. In short, the community owns the school as their property"* (L259-L262).

Improving security issues in rural public primary schools fosters stability, allowing school leaders to focus on implementing 4IR technologies and closing the digital divide, promoting innovation and pupil achievement. Participant eleven expounded:

> *"To lessen the challenges faced by school leaders in implementing 4IR in rural public primary schools, several actions can be taken. First, it is essential to tighten security measures to ensure a safe learning environment"* (L410-L142).

Face verification systems enhance school security by restricting access to only logged-in users, ensuring safety for learners, teachers and school property and expediting the entry process in case of attacks or natural disasters. Participant eleven declared:

> *"I also envision our school having face verification systems to enhance security, ensuring that no one enters the school without a registered profile"* (L25-L27).

Strengthening physical barriers in schools with secure burglar doors ensures protection against uninvited guests, laying the foundation for educational prosperity and providing students with a peaceful state of mind. Participant fourteen shared:

> *"We are strengthening our security burglar doors to safeguard our equipment"* (L86-L87).

The school community implemented an alarm system, security network, cameras, and a cellphone and Wi-Fi policy, fostering a safe, connected, and digitally confident environment. Participant nineteen articulated:

> *"We have requested contributions from parents and installed alarms and cameras. We hired the security guard which is paid by the parents. We also developed a school policy on how to use cellphones and WI-FI"* (L78-L80).

School safety policies that stated how the school would manage its security which include installation of cameras, alarms, and other security devices were viewed. These documents confirmed participants' calls for security upgrades. A record of SGB sessions discussing security breaches, thefts and suggested fixes was also examined. Comparing these minutes gave context to how community alliances are formed and preserved to keep schools safe. Incident reports were reviewed which provide records of any past vandalism and theft incidents at the school and how they were experienced, treated, and resolved. These data provided an overview of the success of implemented security. Documentation about how security cameras and alarms had been installed offered evidence of what was done to improve safety, according to participants. Documents detailing funding for security such as the parents' or locals' contributions to staffing the security company or installing the system were examined.

DISCUSSION

The 4IR integration into schools highlights the transformation of leadership and instruction methods. Female principals are driving this shift and demand professional development to help teachers become proficient at utilising 4IR technologies. For example, as participant three noted, participation in national subject-based WhatsApp groups allows for collaboration among teachers, raising their digital literacy and forming a community to share best practices. It complies with the literature on professional development as a key to better teacher effectiveness and student learning (Sancar, Atal, & Deryakulu, 2021). Seminars on 4IR technologies have been effective at boosting the teachers' ability and willingness to use technology in the classroom, in line with research that promotes ongoing professional development to improve teaching quality (Mhlanga, 2024).

These results also illustrate the importance of strategic leadership in building a culture for 4IR. Initially, there is a School Self-Assessment (SSE) to determine institutional strengths and areas of weakness, then the vision must be aligned with 4IR objectives. This planning is essential for organising resources and activities towards shared objectives and in doing so achieving higher levels of organisational performance (Smith, 2020). Principals who are women help build cooperative networks for teachers, supporting them with guidance and planning. Co-teaching improves not just practice, but also student achievement, according to literature showing that co-teaching produces improved learning outcomes (Letuma, 2023). Even when technologies are

integrated, resistance to change and limited resources remain. Those interviewed stressed ongoing training as a solution to these problems, which suggested that a culture of learning and self-growth is crucial to getting through the technological transitions.

Furthermore, the article highlights stakeholder participation in executing 4IR programmes. Meetings and rounds of feedback with principals, teachers, parents, and community members are essential for the feeling of ownership and shared responsibility for the learning experience. Such participatory leadership fits with the literature supporting stakeholder engagement as a motivator for commitment and resource mobilisation in education (Awodiji & Naicker, 2023). Through the technology tools such as WhatsApp, schools and families can easily communicate regarding school events and homework tasks briefly. This finding supports studies showing that technology improves teacher-family connections to create more inclusive classrooms.

These results also suggest that professional development initiatives and teacher peer-teaching are critical for the adoption of technology. Participants saw an overwhelmingly positive effect of collaborating on teaching methods that encourage teachers to collaborate on best practices and mentor one another in the use of 4IR technology in their classrooms. This is in line with research suggesting that team-based professional development enhances teacher effectiveness and student achievement (Özgenel & Mert, 2019). Yet in rural areas resource constraints and poor training persist. These barriers, participants observed, require government assistance and a strong local support network. Education reform needs institutional support, particularly among marginalised groups (Rasool, 2024).

The discussion also highlights the importance of cultivating a culture of innovation and teamwork in schools. Participants recommended creating environments where teachers and students can feel invited to try 4IR technology. Studies back this up with evidence that innovative school cultures support sustainable learning (Leithwood, 2021). Providing sufficient infrastructure and continuing teacher training is crucial to allow 4IR technologies to be effectively implemented in rural primary schools. The literature shows that space has a huge influence on student learning so it is important to provide adequate space to enable technological integration.

Moreover, partnerships among female school heads, local government agencies, nongovernmental organisations and the private sector is a new mode of resource mobilisation. Participants presented examples of how collaborations helped them secure funding and implement 4IR technologies in their schools. Collaborations like this are critical for collaborating on resources and expertise to achieve sustained education success (Harris & Jones, 2020). But participants also mentioned family financial barriers to paying education costs. School systems are changing to accommodate flexible payment arrangements and other fundraising strategies that do not exclusively rely on parental donations. This trend lines up with scholarship calling for broad-based fiscal policies to promote equal education without further accelerating poverty (Mokate, 2023).

Local fundraising has become a crucial strategy for funding education initiatives as well as engendering stakeholder ownership and ownership of education projects. Participants pointed to co-investment in children's education as part of the community engagement. Understanding the scalability challenges of scaling 4IR programmes requires a holistic plan that includes infrastructure, teacher education, partnerships, cost-savings, social integration and communication efforts.

Finally, the discussion focuses on the need to collaborate across the entire sector (principals, teachers, parents, local community) to overcome the obstacles to education in the Fourth Industrial Revolution. The biggest challenge with adopting 4IR technologies is training and supporting teachers appropriately. Respondents demanded specific training programmes for teachers to incorporate these technologies into the classroom. Recent research has confirmed that

professional development increases teachers' abilities to leverage new technologies to drive learning (Cittadino, 2023). With effective training programmes, schools can help teachers be much more technologically skilled while preparing them to teach a tech-savvy student body.

Further, community support is key to the sustainability of 4IR projects in schools. Including parents also helps create a positive culture for technology use; there is a high association between parental participation and student performance (Naidoo, 2022). Parents can be taught the value of 4IR technologies through open communication channels, and it is by sharing these insights that schools will gain community ownership of school projects while creating equitable access to technology which is key to closing the digital divide (Mhlanga, 2024). Ultimately, female principals who are seeking resources and access to opportunities for rural students can even the playing field while all students are prepared for life after school in an increasingly digital environment.

The findings from this paper have several implications for practice, policy and future studies of educational leadership and technology integration in rural South African schools. The research argues for a holistic, all-inclusive implementation of 4IR efforts. Female headteachers have also shown that engagement with everyone - teachers, parents, community, all brings a feeling of ownership and responsibility that is the key to 4IR programmes succeeding. Having these leaders work collaboratively and sharing information is how they will increase administrative effectiveness and foster learning environments. This means that training for school leaders must include mechanisms for stakeholders, and community, and participation in the adoption of technology improvements.

This study highlights the urgent need for specific interventions and funding to equip rural female school leaders. The government needs to create policies and processes that support the infrastructure, training and financial investments that allow schools to successfully integrate 4IR technologies. This means investing in digital literacy initiatives for students as well as teachers and community members to reduce the digital divide and create a more equitable educational system. The findings allow for further investigation of what female principals in rural areas face when carrying out 4IR programmes. More future studies could explore how leadership differences affect the use of technology in school or the impact of community involvement over the long term on learning. It may also include comparative analyses between urban and rural schools to find specific barriers and facilitators for 4IR integration. The findings from this study highlight the importance of female leadership in educational innovation and the need for appropriate policies and further research to help 4IR efforts to be successful in rural South African schools.

Limitations of the Study

There are limitations of the research on 4IR implementation by female primary school principals in rural public primary schools that need to be acknowledged. Firstly, the sample of twenty female principals, though it offers some information, is not representative of the general population of school leaders who operate in similar situations, thereby making the data less applicable for generalisations. Secondly, the use of qualitative data which include interview and analysis of documents can be subjective as respondents' answers might be biased or based on their perceptions of their experience with 4IR. In addition, because the focus was primarily on female principals, the study can overlook the voices and challenges of male counterparts or other stakeholders in the profession of education leadership. Moreover, the study is mostly focused on strategies without adequately exploring the negative impacts or failures of 4IR initiatives in a manner that could give a more nuanced picture. And finally, due to the changes in technology and how it is incorporated into education, findings could soon be outdated and will require ongoing studies to determine the impacts and sustainability of these rural-based initiatives.

CONCLUSION

The study provides several important observations about female primary school principals in rural public primary schools and their experience with the 4IR. Women are invited to improve their emotional intelligence, especially empathy and active listening, to make sense of the needs of both teachers and students. There is also much emphasis on having 4IR technologies focused professional development courses. Mentoring by experienced teachers and continual training are critical to give teachers the skills they need. It is important to do need assessments that include analysis of current resources, infrastructure, and teacher skills. This allows for the discovery of bottlenecks and the tailoring of implementation roadmaps for 4IR projects. Women leaders can create an innovative culture at school by enabling risk taking and mistakes. This is an excellent method not only for the teachers but also for the students. Collaborations with governments and NGOs are necessary for the funding and resources to implement technologies in rural schools.

Understanding how 4IR might work in the long term could tell us more about its effectiveness in rural areas. It is worth comparing female principal experiences from different regions or countries because there might be common challenges and best practices to draw on. It would be helpful to investigate the role of certain 4IR technologies in student engagement and learning. Identifying structural barriers that prevent female principals from fully embracing 4IR might help inform policy. These findings highlight the transformative power of 4IR in rural education, especially when enacted by compassionate and creative female principals. Emotional intelligence, career growth, and partnership become the underlying strategy to success. Yet it is important to address the issues of these leaders if access to educational resources is to be equitable. Stakeholders can support gender equality and work towards a more inclusive educational environment for female leaders and the betterment of student learning during the 4IR.

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