Exploring rural South African science teachers' self-efficacy in integrating computer simulations in instruction

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Abstract

Using computer simulations in science education can facilitate the achievement of several educational objectives, including a thorough grasp of scientific concepts and an understanding of the scientific method. This research aimed to evaluate the extent of rural science educators' technology integration self-efficacy when using simulations in teaching. The research was guided by Bandura's (1986) social cognitive theory and focused on four key influencers of self-efficacy in educators: enactive mastery experience, vicarious experience, verbal persuasion, and affective state. The study's demographic was all science educators in a rural district, with participants selected through convenience sampling. The survey instrument's reliability and validity were established through exploratory and confirmatory factor analyses. The outcomes indicated that the science educators possessed a high level of self-efficacy in integrating technology through simulations, with no notable differences based on gender or education level. There was a statistically significant effect of teaching experience and school socioeconomic factors on the educators' technology integration self-efficacy.

Keywords: technology integration self-efficacy, enactive mastery experience, vicarious experience, verbal persuasion, affective state and simulations

INTRODUCTION

There are concerted efforts to promote and support computer simulations to improve science education, particularly in settings lacking resources. One initiative that has created the platform for increasing computer simulation access and appropriation is PhET Global, run by the University of Colorado. The initiative provides professional development in computer simulations to selected mathematics and science teachers drawn from Africa and South America. PhET presents webinars where researchers share their teaching practices with computer simulations. Research on computer simulation use has provided evidence of their efficacy in enhancing conceptual understanding of science content, developing science process skills, and creating interest in learning (Bo et al., 2018; Smetana & Bell, 2012; Tsoka et al., 2023). Conceptual understanding is promoted because the linguistic demands of the English language do not constrain learners. The visuals help learners to form correct mental representations of abstract concepts.

Despite computer simulations' potential to elevate learning outcomes in physical sciences in rural regions, there remains a dearth of evidence on their adoption by educators in these areas. As seen in physical science performance metrics, rural schools are still outstripped by their urban counterparts in terms of learning quality. Anecdotal indicators suggest a reluctance among educators to incorporate simulations into their teaching methodologies, with integration often described as feeble and fraught with difficulties (Bo et al., 2018).

This research explored and measured educators' self-efficacy in rural schools concerning using computer simulations in teaching. It cautions against academic practices that could isolate and disenfranchise educators by mandating specific methodologies for using computer simulations. It critiques the 'deficit' model of professional development–which presupposes the deficiency of the teachers' knowledge base, requiring augmentation or correction (Kennedy, 2005) as particularly counterproductive (Sugrue, 2016). The research advocates for formulating teaching strategies

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that are contextually appropriate, relevant, and sustainable with computer simulations, aiming to enhance the educational quality in rural schools, which are especially impacted by a lack of teaching resources.

Computer simulations are emerging, novel learning tools that simulate various materials and apparatus used in science laboratories. They are also used to simulate natural scientific phenomena virtually. They assist students in conceptualizing abstract scientific theories (McElhaney et al., 2015; Wu & Huang, 2007) and develop, assess, and refine theoretical models to elucidate those phenomena (Schwarz et al., 2009). With their potential pedagogical benefits (cognitive, affective, and behavioral), computer simulations could counter the prevailing teacher-centric instructional methodologies common in rural schools. The teaching methodologies in question fail to cultivate learners equipped with critical thinking, creativity, imagination, effective communication across various platforms, the ability to collaborate and self-guided lifelong learning skills (Department of Basic Education, 2011). Concurrently, there's a national demand for a scientifically knowledgeable populace that exhibits characteristics from reasoning and impulse control to taking calculated risks and logical, cooperative thinking.

Despite the transformative promise of computer simulations for education in rural regions, the scant adoption by educators is concerning. According to Daya and Laher (2020), investigations at individual schools reveal that the digitalization of teaching and learning in South Africa is far from being achieved. Digital technology integration hasn't become commonplace within the South African educational context. Research (Masango et al., 2019; Padayachee, 2017) identifies several obstacles teachers face in adopting digital tools, including insufficient computer infrastructure, a lack of digital literacy, limited professional development opportunities concerning digital tools, classroom overcrowding, time restrictions, and an overloaded curriculum. Moreover, Tachie (2020) found a hesitance among educators to embrace digital technology even when it is accessible.

While acknowledging these challenges as valid, this study aims to investigate the self-efficacy beliefs of rural educators. There's a gap in research, specifically regarding South African educators' self-efficacy in

utilizing computer simulations for teaching. Morris et al. (2017) argue that human actions often reflect personal beliefs about capability rather than actual skill. People with strong self-efficacy beliefs regarding their skills tend to possess an internal locus of control and view their actions as determinants of outcomes. Consequently, they approach challenges with creativity and curiosity, believing they can surmount their deficiencies through professional development or further research to expand their knowledge (Morris et al., 2017). Conversely, individuals with low self-efficacy beliefs, holding an external locus of control, perceive outcomes as the result of external factors and typically avoid challenges.

There has been an increasing interest in teacher self-efficacy within educational research and practice across various disciplines (Alibakhshi et al., 2020; Demir & Ellett, 2014; Makopoulou et al., 2021). A substantial amount of literature discusses how self-efficacy influences educators' confidence in adopting effective teaching strategies and their personal belief systems regarding education (Pearman et al., 2021). Significant research has also looked into pre-service teachers' use of technology in teaching (Jere & Mpeta, 2024); beliefs around science teaching environments (Lumpe et al., 2014); the link between professional development and teacher efficacy (Ross & Bruce, 2007); the correlation between self-efficacy and science teaching quality (Khourey-Bowers & Simonis, 2004); and how science content knowledge impacts science teaching efficacy (Lakshmanan et al., 2011). However, there appears to be a lack of specific studies exploring rural science educators' self-efficacy in using computer simulations in their teaching.

As for the relationship between years of teaching experience and technology self-efficacy, empirical findings have been inconsistent, indicating the need for further research. For instance, Akiri and Dori (2022) found that more experienced educators displayed higher levels of teaching efficacy than their novice counterparts, aligning with other studies' findings (Cantrell et al., 2003; Liang & Richardson, 2009). In contrast, Inan and Lowther (2010) observed that computer proficiency decreased with teaching experience. Research on the impact of gender on educators' self-efficacy beliefs in integrating digital technologies has also produced mixed

outcomes. Where Adams (2002) noted female educators had better technology integration skills, Kwon et al. (2019) reported higher self-efficacy among male educators in employing mobile technology in teaching.

Purpose of Study

Given the literature underscoring the importance of self-efficacy in predisposing individuals towards certain actions, this study delved into the technology integration self-efficacy of rural educators, specifically in the context of using computer simulations for teaching. Only a handful of empirical studies have investigated the contributing factors to educators' self-efficacy in technology integration. This research focused on identifying and analyzing factors that enhance educators' self-efficacy in integrating technology into their teaching practices. Additionally, it assessed the levels of self-efficacy among educators regarding technology integration. The research sought to fill the gap in existing literature regarding the impact of variables such as gender on educators' confidence in employing digital technology in their instruction, as highlighted by Šabić et al. (2022). The objective was to create and validate an instrument for measuring educators' self-efficacy in technology integration and to utilize this tool to address the study's research questions. The primary research questions were:

1. What is rural physical science educators' level of technology integration self-efficacy?
2. What are the effects of gender, teaching experience, level of education and school socioeconomic factors on the educators' technology integration self-efficacy?

THEORETICAL FRAMEWORK: TEACHER SELF-EFFICACY

Grounded in Bandura's (1986) social cognitive theory, this study explored educator self-efficacy. Bandura (1986) introduced the concept of self-efficacy, advocating for an agent-centered view of human behavior (de la Fuente et al., 2023; Morris et al., 2017). He suggested that through a system of triadic reciprocal determinism, individuals contribute causally to their own motivation and behaviors (Bandura, 1989). Bandura (2011) believed individuals learn from unsuccessful attempts, overcoming challenges through perseverance and dedication.

Self-efficacy is defined by Bandura (1997) as an individual's belief in their ability to successfully complete tasks and handle obstacles that may impair performance or behavior. It is a critical determinant of an individual's effort and decision to undertake a task, rooted in the belief of its achievability. Consequently, fostering teachers' self-efficacy is paramount for effectively integrating computer simulations into teaching practices. High self-efficacy encourages educators to experiment with new teaching methods and actively engage in professional discussions about curricula to serve their students better (Fullan, 2014).

According to Bandura (1997), self-efficacy beliefs are influenced by four main sources: enactive mastery experiences (EMEs), vicarious experiences (VEs), verbal persuasion (VP), and affective states (ASs). EMEs are personal teaching experiences that result in student learning improvements. Bandura (1997) argues that these are the most influential sources of efficacy information, providing concrete evidence of success in challenging situations. VEs involve observing peers navigate difficult tasks successfully. Lumpe et al. (2014) suggest these experiences are impactful when the observer identifies with model's struggles and successes.

VP involves convincing educators through dialogue that they can manage previously overwhelming tasks (Bandura, 1997). Expert educators can facilitate this by sharing successful teaching strategies and their impacts on student outcomes, fostering positive beliefs in personal efficacy (Lumpe et al., 2014). ASs influence how educators perceive their efficacy, with positive emotions bolstering it and negative emotions diminishing it. Educators' confidence levels can create a cycle of success or failure (Lumpe et al., 2014). The influence of these sources on an educator's self-efficacy varies based on several factors, including existing skills, interactions with others, task difficulty, and self-reflection (Demir & Ellett, 2014). These sources were considered in the development of the study's questionnaire.

MATERIALS AND METHODS

The study employed a cross-sectional survey design, allowing for the efficient collection of self-efficacy data from a broad population of teachers. Surveys are an effective means to gather large-scale data for drawing conclusions and making informed decisions. The instrument's content validity was verified by a panel of three science education experts external to the study, ensuring the questionnaire was appropriate and comprehensive for the study's aims.

Sampling

This study involved physical science educators from schools ranked in quintiles 1 to 5 within the Vhembe West District. In South Africa, public schools are categorized into five quantiles, with a quantile of one school being the least affluent and a quantile of five schools being the most affluent, as noted by White and Van Dyk (2019). Teachers were chosen through convenience sampling methods. The study received ethical approval from the University Research Ethics Committee (Reference No. FHSSE/23/PCEM/01/2206), and the Limpopo Department of Education authorized the research. A questionnaire was distributed via a Google Form link to all natural and physical sciences

Table 1. Correlation matrix (principal component analysis with oblique Oblimin rotation)

Item	Factor loadings				C
	EME	VE	VP	AS	
EM1. I have knowledge of computer simulations.	0.673				0.459
EM2. I teach with computer simulations.	0.703				0.659
EM3. My teaching with computer simulations is informed by theory.	0.807				0.647
EM4. My instructional practice has improved through the use of computer simulations.	0.859				0.776
EM8. Computer simulations help learners understand scientific concepts better than dictating notes.	0.897				0.802
EM9. There is a difference in learner performance when teaching with computer simulations compared to dictating notes.	0.861				0.741
EM10. My understanding of content has improved with teaching with computer simulations.	0.809				0.660
VE2. I have observed colleagues teaching with computer simulations.		0.930			0.841
VE3. Colleagues share their knowledge of computer simulations with me.		0.933			0.890
VE4. Watching other colleagues teaching with computer simulations motivates me to use them in my class.		0.862			0.803
VP1. The school encourages us to use computer simulations when teaching.			0.901		0.815
VP2. The district promotes the use of computer simulations when teaching.			0.865		0.738
VP3. The district supports us with professional development in using computer simulations in our teaching.			0.854		0.729
VP4. Professional development in computer simulation teaching would help me use them in my class.			0.835		0.720
AS1. I am comfortable/confident in teaching with computer simulations.				0.861	0.803
RAS2. I feel anxious when teaching with computer simulations.				0.853	0.768
RAS3. Teaching with computer simulations is time-consuming.				0.884	0.749

Note. C: Communalities

teachers in the district, receiving responses from 125 teachers.

Instrument

The research employed the teacher technology self-efficacy survey, crafted by the authors based on Bandura's (1997) four self-efficacy influencing constructs: EMEs, VEs, VP, and ASs. This initial version of the survey had 22 items rated on a four-point Likert Scale, including two items (AS2 and AS3) that were negatively phrased. These items were reverse-scored in the analysis, transforming them into RAS2 and RAS3, with higher scores indicating increased self-efficacy post-reverse coding.

Exploratory Factor Analysis

As the research instrument was developed by the researchers and had not been used previously, the first step was to validate the instrument. This was carried out through exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and partial least squares structural equation modelling (PLS-SEM), utilizing SPSS version 29, Amos version 29, and SmartPLS version 4.1.0 for all statistical analyses. The aim was to ascertain the survey instrument's reliability and validity. EFA identified latent variables within the survey instrument, applying principal component analysis and Oblimin rotation with Kaiser normalization. Bartlett's test of sphericity confirmed the correlation matrix was significant, $\chi^2(136)$ = 1305.41, $p < .001$, with a Kaiser-Meyer-Olkin measure

of 0.829, indicating suitability for factor analysis (Watkins, 2018). Observations that crossed-loaded on multiple factors were removed (items E5, E6, E7, and VE1), and we reran the EFA. The final model revealed that the questionnaire had four factors with items with eigenvalues above 1, accounting for 74.16% of the total variance. All items had loadings above 0.5, as shown in **Table 1**. All communalities were greater than 0.5 except for EM1, which we decided to retain as it was close to the acceptable value of 0.5.

Confirmatory Factor Analysis

The CFA conducted with IBM SPSS Amos version 29 aimed to finalize the model structure. In this analysis, the maximum likelihood, which is robust against deviation from normality (Groß, 2021; Olsson et al., 2000), was the procedure applied to determine the model parameters of the proposed model with four latent variables–EME (factor 1, F1), VE (F2), VP (F3), and AS (F4). The final model with these four latent variables is shown in **Figure 1**. We used goodness of fit index (GFI), normed fit index (NFI), Chi-square goodness, relative fit index (RFI), incremental fit index (IFI), comparative fit index (CFI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA) to ascertain whether the values were within acceptable ranges. For a model to be acceptable, χ^2 should be small or non-significant (Marsh & Balla, 1994).
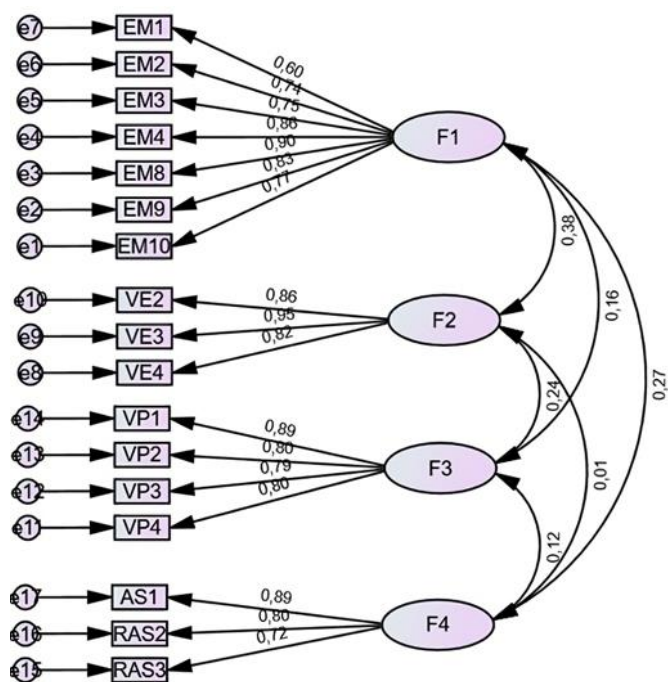
Figure 1. CFA model of the teacher technology self-efficacy questionnaire (Source: Authors' own elaboration, using SPSS version 29)

Table 2. Goodness of fit measures for the final model

FM	Cut-off values	Source	Model values	I
p	IS	Marsh and Balla (1994)	0.063	A
NFI	> .90	Bentler and Bonett (1980)	0.901	A
TLI	>.95	Hu and Bentler (1998)	0.977	E
CFI	> .90	Bentler and Bonett (1980)	0.981	E
IFI	>.90	Bentler and Bonett (1980)	0.981	E
RMR	< .08	Hu and Bentler (1998)	0.052	E
RMSEA	< .08	Hu and Bentler (1998)	0.042	E

Note. FM: Fit measure; IS: Insignificant; I: Interpretation; A: Acceptable; & E: Excellent

Using these criteria, the final model had a good fit, $\chi^2(113) = 137.995$; $\chi^2/df = 1.22$; $p = .055$, as χ^2 was statically nonsignificant, and χ^2/df was less than 3 (Marsh & Balla, 1994). As χ^2 as a fit measure is affected by sample size, we considered other fit measures. These fit measures were satisfactory, as shown in **Table 2**.

Reliability and Construct Validity

Following the assessment of the fit of the model, the subsequent phase involved evaluating the reliability and validity of the questionnaire. This evaluation was carried out with SmartPLS version 4.1.0, employing PLS-SEM for generating the outer measurement model. This method is suggested for instances where the data may not adhere to a normal distribution, as noted by Dijkstra and Henseler (2015) and Henseler et al. (2015). The process verified the questionnaire's reliability and validity by examining internal consistency, composite reliability, and average variance extracted (AVE) for

Table 3. Construct reliability and validity

Construct	Cronbach's alpha	Composite reliability		AVE
		Rho_a	Rho_c	
AS	0.844	0.932	0.893	0.738
EME	0.902	0.918	0.925	0.674
VE	0.905	0.916	0.940	0.840
VP	0.889	0.916	0.922	0.747

Table 4. Discriminant validity–Fornell-Larker criterion

Construct	AS	EME	VE	VP
AS	**0.859**			
EME	0.289	**0.821**		
VE	0.020	0.374	**0.916**	
VP	0.099	0.189	0.202	**0.865**

Table 5. Discriminant validity–HTMT matrix

Construct	AS	EME	VE	VP
AS				
EME	0.273			
VE	0.036	0.404		
VP	0.106	0.204	0.223	

reliability and construct validity. The Fornell-Larker criterion and the Heterotrait-Monotrait (HTMT) ratio were also applied to assess discriminant validity (Hair et al., 2014, 2019; Sarstedt et al., 2021). The findings are compiled in **Table 3** and **Table 4**.

The values for Cronbach's alpha concerning scales AS, EME, VE, and VP surpassed the threshold of 0.7, as Hair et al. (2014) suggested, indicating sufficient internal consistency. The scales' composite reliability values ranged from 0.75 to 0.95 (Hair et al., 2019), affirming their reliability. Convergent validity, the measure of a construct's correlation with its indicators, evaluated through the average variance extracted, should exceed 0.5 (Hair et al., 2014, 2019). Given that all constructs presented an AVE above 0.5, the scales demonstrated satisfactory convergent validity.

Discriminant Validity–Fornell-Larker Criterion and Heterotrait-Monotrait Ratio

Discriminant validity, which measures the extent to which a construct is empirically distinct from other constructs (Sarstedt et al., 2021), was examined using the Fornell-Larker criterion and HTMT. Discriminant validity is achieved when the square root of AVE (bold values in **Table 4**) is higher than all correlations between the constructs (all other values in **Table 4**) (Fornell & Bookstein, 1982). As a visual inspection of **Table 4** shows this to be the case, we deduce that there was evidence of discriminant validity in these constructs.

Given that all HTMT values were below 0.85 (shown in **Table 5**), the questionnaire was determined to have acceptable discriminant validity (Henseler et al., 2015).

Following a thorough analysis via EFA, CFA, and PLS-SEM, which confirmed the instrument's validity

Table 6. Interpretation of weighted mean values

Rating	Weighted mean range	Verbal interpretation
1	1.00-1.75	Very low
2	1.76-2.51	Low
3	2.52-3.27	High
4	3.28-4.00	Very high

and reliability, it was utilized to assess the level of technology integration self-efficacy among science teachers regarding the use of computer simulations, as well as to investigate the impact of various factors on their self-efficacy.

RESULTS

In the initial question of the study, descriptive statistics were employed to assess the self-efficacy in technology integration among physical science educators, whereas inferential statistics were utilized in the subsequent question to explore disparities in self-efficacy beliefs based on variables such as gender, experience, education level, or quantile. Our evaluation adhered to the interpretive guidelines proposed by Pimentel (2010), which are concisely represented in **Table 6**. **Table 6** provides insights into the interpretation of the weighted mean scores concerning physical science teachers' self-efficacy in integrating technology.

Physical Sciences Educators' Extent of Technology Integration Self-Efficacy

Enactive mastery experience

Table 7 displays the frequencies, weighted means, and standard deviations pertaining to the educators' responses regarding EME. A significant number of respondents acknowledged their familiarity with (EM1, 66.7% agree or strongly agree) and application of computer simulations in their teaching practices (EM2, 60.2% agree or strongly agree). Most did not rely on theoretically informed simulations (EM3, 56.9% disagree or strongly disagree). Half of the educators concurred that their teaching efficacy improved by incorporating simulations (EM4). A substantial portion attested that simulations facilitate learner comprehension more effectively than traditional note dictation (EM8, 59.4% agree or strongly agree). Utilizing computer simulations in teaching was viewed as a means to enhance academic performance (EM9, 69.9% agree or strongly agree). Roughly half of the educators felt their science content knowledge was enriched by employing computer simulations (EM10). The EME scale's weighted mean of 2.54 indicated a high level of EME among the educators.

Vicarious experience

Descriptive statistics on VE are presented in **Table 7**. Most educators reported observing their colleagues teaching with computer simulations (VE2, 59.3% agree

or strongly agree). They also indicated that their colleagues share the knowledge of computer simulation used in teaching (VE3, 56.9% agree or strongly agree). A majority of educators believe that watching other educators use computer simulations in instruction was motivating (VE4, 73.2% agree or strongly agree). With a VE weighted mean of 2.70, the data suggest that educators perceive a high self-efficacy concerning technology integration through VE.

Verbal persuasion

A majority of educators reported encouragement from their schools to incorporate computer simulations in teaching (VP1, 68.3% agree or strongly agree) and received support from their district in this endeavor (VP2, 66.7% agree or strongly agree) (**Table 7**). Educators also acknowledged district-level support for professional development involving computer simulations (VP3, 62.6% agree or strongly agree). They believed such professional development was instrumental in facilitating the use of simulations in their classes (VP4, 69.1% agree or strongly agree). The VP dimension's weighted mean of 2.80 reflected a high self-efficacy belief among educators.

Affective state

Educators expressed comfort and confidence in using computer simulations (AS1, 78.9% agree or strongly agree) (**Table 7**). They disagreed that using simulations in teaching induced anxiety (RAS2, 82.2% disagree or strongly disagree) or that it was time-consuming (RAS3, 78% disagree or strongly disagree). The AS's weighted mean of 3.12 indicates a high level of self-efficacy.

Teachers' level of technology integration self-efficacy

Overall, the comprehensive weighted mean rating for educators' technology integration self-efficacy stood at 2.54 (**Table 7**), signaling a high level of self-efficacy in technology integration among science educators, as per the standards set by Pimentel (2010).

Effects of Various Factors on Self-Efficacy in Technology Integration

Inferential statistics were employed to explore if significant variations exist in technology self-efficacy across gender, experience, education level, and quantile. Before conducting parametric tests, the data's normality was assessed. The Shapiro-Wilk test indicated significant deviation from normality, with all items showing significant p values (W[123] = 0.978, $p < .05$), leading to the utilization of non-parametric tests.

Hypotheses Reviewed

H1. There is a significant difference in technology self-efficacy between male and female teachers.

Table 7. Descriptive statistics of technology integration self-efficacy

Item	f(%)				Mean	Standard deviation	Interpretation
	SD (1)	D (2)	A (3)	SA (4)			
Enactive mastery experience							
EM1	4 (3.3)	37 (30.1)	61 (49.6)	21 (17.1)	2.80	0.75	High
EM2	33 (26.8)	16 (13.0)	59 (48.0)	15 (12.2)	2.46	1.02	Low
EM3	34 (27.6)	36 (29.3)	37 (30.1)	16 (13.0)	2.28	1.01	Low
EM4	24 (19.5)	38 (30.9)	46 (17.4)	15 (12.2)	2.42	0.94	Low
EM8	20 (16.3)	30 (34.4)	50 (40.7)	23 (18.7)	2.62	0.97	High
EM9	11 (8.9)	26 (21.1)	67 (54.5)	19 (15.4)	2.76	0.82	High
EM10	23 (18.7)	38 (30.9)	44 (35.8)	18 (14.6)	2.46	0.96	Low
Vicarious experience							
VE2	16 (13.0)	34 (27.6)	56 (45.5)	17 (13.8)	2.60	0.885	High
VE3	20 (16.3)	33 (26.8)	49 (39.8)	21 (17.1)	2.58	0.958	High
VE4	14 (11.40)	19 (15.4)	52 (42.3)	38 (30.9)	2.93	0.960	High
Verbal persuasion							
VP1	8 (6.5)	31 (25.2)	62 (50.4)	22 (17.9)	2.80	0.809	High
VP2	8 (6.5)	33 (26.8)	55 (44.7)	27 (22.0)	2.82	0.850	High
VP3	6 (4.9)	40 (32.5)	54 (43.9)	23 (18.7)	2.76	0.811	High
VP4	5 (4.1)	33 (26.8)	66 (53.7)	19 (15.4)	2.80	0.734	High
Affective state							
AS1	9 (7.3)	17 (13.8)	54 (43.9)	43 (35.0)	3.07	0.885	High
RAS2	6 (4.9)	16 (13.0)	35 (28.5)	66 (53.7)	3.31	0.879	Very high
RAS3	7 (5.7)	20 (16.3)	65 (52.8)	31 (25.2)	2.98	0.804	High
Note. SD: Strongly disagree; D: Disagree; A: Agree; SA: Strongly agree; Overall weighted mean = 2.54							

The Mann-Whitney U test, assessing gender's influence on educators' self-efficacy to integrate technology, found no significant difference between males (Md = 47.5, n = 52) and females (Md = 48.0, n = 71), z = -0.356 U = 1776.5, p = .722, thus rejecting **H1**.

H2. There is a significant difference in technology self-efficacy between educators with ten years or less teaching experience and educators with more than ten years of teaching experience.

H2 proposed a significant difference in technology self-efficacy among educators with varying lengths of teaching experience. Results from the Mann Whitney U test displayed a significant difference in the self-efficacy of educators with a decade or less of experience (Md = 49.0, n = 65) versus those with more (Md = 45.5, n = 58), U = 1231.5, z = -3.314, p < .001. This confirmed **H2**, illustrating that educators with less experience possess higher technology integration self-efficacy.

H3. There is a significant difference in technology self-efficacy between educators with a diploma, bachelor's degree, or master's degree and those with a PhD degree.

H3 considered if education level (diploma, bachelor's, master's, or PhD degree) impacted technology self-efficacy. Analyzed through the Kruskal-Wallis test, the outcome showed no significant difference across educational levels (χ^2(3, N = 123) = 5.975, p = .113), resulting in **H3**'s rejection despite PhD holders having a higher median value.

H4. There is a significant difference in technology self-efficacy between educators teaching in quantiles 1, 2, 3, 4, and 5.

H4 examined whether teaching in different quantiles affected technology self-efficacy. The Kruskal-Wallis test revealed a significant difference across quantiles (χ^2(4, N = 123) = 12.777, p < .05). Educators in quantile 1 (Md = 48.5) and quantile 2 (Md = 44.0) had the lowest educator technology integration self-efficacy compared to educators in quantile 3 (Md = 50.5), quantile 4 (Md = 49.5) and quantile 5 (Md = 50.0).

DISCUSSION

This research uncovered that science educators possess a high level of self-efficacy in integrating technological tools such as computer simulations into their teaching. This is significant because it highlights that with adequate support, science teachers in less urban areas are likely to embrace the use of simulations in their teaching methods, which can enhance the learning experience in the sciences. This aligns with Kent and Giles (2017), who noted a high level of self-efficacy among educators in incorporating technology. On the contrary, Boeve-De Pauw et al. (2022) observed that teachers exhibited only moderate confidence when teaching STEM in high-tech informal learning settings.

The study also explored whether there were any significant differences in educators' self-efficacy in technology integration based on their gender or educational qualifications. It was found that neither of these factors significantly influenced the teachers' self-

efficacy in technology integration. This aligns with the findings of Boeve-De Pauw et al. (2022) regarding gender impact, while Šabić et al. (2022) discovered that older male teachers in Croatia showed slightly higher information and communication technologies usage confidence than their female peers, though the difference was minimal and not significant among younger educators. These observations suggest that students could benefit equally from the technological integration efforts of both male and female teachers.

The study revealed that in South Africa, the level of educational qualifications among teachers did not drastically affect their confidence in integrating technology. Most teachers held a bachelor's degree, and while those with a PhD displayed somewhat higher self-efficacy levels than those with master's or bachelor's degrees, this trend was not statistically significant across different educational levels. This suggests that having a higher level of education could increase perceived technological proficiency and, consequently, a positive attitude towards technology use in teaching, supporting Dogan et al. (2020)'s findings.

Socioeconomic factors of schools were also examined, demonstrating that educators from less affluent schools (quantile 1 and quantile 2) reported lower technology integration self-efficacy than their counterparts in wealthier institutions (quantiles 3, 4, and 5). This could be due to differences in available technical infrastructure and support, as limited technological resources have been shown to adversely affect educators' confidence and their ability to incorporate technology in teaching (Hamutoğlu & Başarmak, 2020).

Additionally, the research found that an educator's experience played a significant role in their technological integration self-efficacy. According to Russel et al. (2003), educators with under ten years of teaching experience were more confident than those over ten years. This suggests a decrease in technology integration self-efficacy with increased teaching experience, indicating the need for targeted professional development opportunities for more experienced educators.

CONCLUSION

This study revealed that rural science educators had high technology integration self-efficacy. This suggests that despite their challenges, such as unreliable internet connectivity and limited computer infrastructure, these teachers would utilize the few resources to integrate computer simulations into science teaching. This aligns with the social cognitive theory, which postulates an agentic theory of human behavior that supports the idea that individuals with high self-efficacy can overcome obstacles. Therefore, we recommend that more efforts be put in place to accelerate the digitalization of education in schools in South Africa and beyond to attain the essential goals of science teaching. The study showed that schools in poorer areas had lower self-efficacy, and this further implies that more resources should be put into those areas to enhance science teaching efficacy.

The study also acknowledges limitations such as a small sample size and reliance on self-reported data. We recommend that the study be repeated with a higher sample size and mixed-method designs to observe teachers' integration of simulations in practice.

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