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Innovative Strategies for Integrating Technology into Agricultural TVET Programs in South African

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ABSTRACT

Integrating technology into Technical and Vocational Education and Training (TVET) is a smart move to align agricultural education with the demands of the global economy. This mixed-methods approach exposes infrastructure and training inadequacies that impede market-oriented teaching by comparing the usage of modern agricultural equipment and basic classroom ICT in TVET colleges. Data was gathered from 482 National Accredited Technical Education Diploma (NATED) and National Certificate of Vocational NC(V) students in three chosen TVET colleges using a questionnaire and observation schedule. Pearson chi-square tests and descriptive analysis showed that most variables had extremely significant associations ($P<0.05$). The findings indicated that students view technology as a suitable tool to utilize, but they are hampered by poor connectivity and a shortage of technical learning tools. Technological tools should be made available to TVET colleges to facilitate digital training in their programs. The modern existing technologies can be integrated to enhance theoretical learning, professional skills, and the noticeable "digital divide." Therefore, TVET colleges ought to invest in robust ICT infrastructure and specialized professional development. To determine how precision agricultural technologies affect TVET students' employment after graduation, more long-term research is advised.

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INTRODUCTION

Global economies are drastically altered by the transformation of technology integration, not only gadgets but also educational sectors, including Technical and Vocational Education and Training (TVET) colleges. South African TVET colleges must immediately shift from outdated courses to like precision and digital farming to preserve food security and satisfy the existing societal needs. The majority of agricultural TVET programs encounter challenges, including infrastructure, specialized farming equipment, frequent network disconnections, and a lack of lecturer training. This indicates a gap in classroom execution of agricultural programs. As a result, TVET lecturers are ill-prepared to use modern digital tools in their teaching methods. A comprehensive support strategy for both lecturers and students is urgently needed to bridge this gap and ensure graduates acquire the practical, market-aligned competences necessary to manage the contemporary agricultural sector.

Research on challenges and innovative strategies of integrating technology in TVET colleges offering agricultural programs is still lacking in South Africa. Studies conducted focused on general issues. For instance, Smidt and Jokonya (2022) examined digital adoption among small-scale farmers, and Moloi (2021) investigated the Fourth Industrial Revolution (4IR) in colleges, and Bontsa et al. (2023) investigated how South African smallholder farmers used digital technologies. However, a thorough investigation into the innovative strategies for integrating technology into agricultural education was required, with an emphasis on looking into challenges they encounter when integrating technology into teaching and learning agricultural programs. As a result, four stages from Kotrlik-Redmann's (2003) served as a framework for this study, which includes exploration of technology integration, experimentation with technology integration, adoption of technology integration, and advanced technology integration within TVET colleges.

The purpose of using this theory was to identify the key areas that could enhance their technology integration. Aligning vocational education with modern farming methods requires a change from strict theoretical training to practical, hands-on problem-solving to strict technology integration (Hamzah, Abdullah & Ma, 2024). A vocational paradigm where curriculum modernization and technology integration, especially in modern areas like precision farming, lay the framework for job-related performance envisaged by TVET colleges to produce competitive graduates (Li, 2024). The novelty of this research is its contextualized, empirically grounded diagnostic approach to highlight the challenges and strategies, particularly the disconnect between basic classroom ICT and specialized, industry-standard agricultural technologies within South African TVET colleges, even though existing literature generally supports digital transformation. This study raises the following specific research questions and validates the strategies required for modern education:

a) What training and pedagogical requirements exist for the teaching and learning of agricultural programs in TVET colleges?
b) What infrastructural and resource shortages prevent the use of modern agricultural equipment in place of more basic ICT?
c) How can lecturers and students be empowered to effectively use precision agricultural technologies in vocational curricula?

LITERATURE REVIEW

Exploration of Technology Integration

Exploring agricultural content utilizing technology is the first step to transform how teaching and learning ought to be implemented in TVET colleges. Although challenges including poor infrastructure and support from relevant stakeholders still prevail in TVET colleges (Netshipale, 2024). Searching for innovative strategies to integrate technologies helps graduates to be ready for any demands expected in the global digital market (Makarova & Makarova, 2018). The existing paradigm does not, however, provide a clear "evolutionary imperative" for instructional strategies, which leaves a gap. As a result, this analysis concentrated on the particular difficulties and innovative approaches needed to integrate cognitive technology into TVET agriculture curricula. In order to close the digital divide and offer the required instruments for access, this calls for more robust governmental interventions (Mathebula et al., 2025). However, resources by themselves are insufficient, and rather than being viewed as a simple "add-on," technology must be incorporated with educational practices. A perfect alignment of topic knowledge, pedagogy, and technological tools is necessary for transformation in order to ensure that technology integration takes place (Jibril & Adedokun-Shittu, 2024). This suggests carrying on with transformative training, which is better for TVET graduates.

In TVET colleges, technology integration is a crucial first step that is primarily used to transform teaching and learning methods. Because the technology to be used could convey teaching and learning closer to current field practices, this phase helps lecturers and students in bringing classroom sessions closer to actual farming methods. For example, students may be better equipped to handle contemporary workplace difficulties if they engage in experiential learning through the exploration of agricultural content with technology integration (Sephokgole et al., 2023). Additionally, TVET graduates are shaped to be prepared for any issues related to the modern operation of agricultural practices when teaching and learning techniques are in line with technology integration. Additionally, TVET graduates are shaped to be prepared for any issues related to the modern operation of agricultural practices when teaching and learning techniques are in line with technology integration. By putting this technique into practice, TVET colleges may be able to guarantee that only highly qualified graduates are accepted. Understanding more general concepts and their difficulties is not enough to be competent in integrating technology. For example, learning performance and pedagogical practices are enhanced when the agriculture subject is explored through technology employing techniques like simulations and multimedia tools (Staneviciene & Žekienė, 2025). Additionally, the approach improves instructional strategies that support different learning styles and validate the effects of technology integration (Chandrasekera et al., 2025). This flexibility eventually leads to improvements in high performance and technical instruments in educational institutions.

Experimentation with Technology Integration

Utilizing technology to experiment agricultural curriculum is essential because it allows TVET colleges to adapt modern teaching and learning to global trends and practices. According to Mena-Guacas et al. (2025), this phase, which is in line with agricultural teaching and learning methodologies, enhances contemporary practice and meets educational needs and outcomes. Furthermore, Kabato et al. (2025), emphasized changes to smart farming which enhances to align graduates with the current demands in industries. This innovation that has progressed from traditional to modern farms should be supported by the educational reforms in TVET colleges. However, the process is still hindered by a lack of modern tools, which are still expensive and difficult to handle, causing the nation to fall behind in technological progress. The practice of agricultural production is expected to be improved in the future by a variety of technology technologies. Operational competencies are therefore essential to maintaining the environment and continuing to produce more food. This approach improves productivity and ensures product quality in addition to developing operational competency skills (Getahun et al., 2024). Additionally, distinctive characteristics include protection from inclement weather, which could maximize agricultural output. Srinivasan and Yadav (2024) claim that there are too many elements in agricultural technology that support smart farming, such as soil moisture sensors for agricultural use and precision scheduling like smart irrigation. The necessity for TVET colleges to match their curricula with contemporary agricultural practices is highlighted by this action. In order to generate qualified graduates, TVET curricula should include modernized training where technology helps teaching and learning activities (Jellason, Robinson & Ogbaga, 2021).

Utilizing technology to experiment with the agricultural curriculum is essential because it allows TVET colleges to adapt modern teaching and learning to global trends and practices. According to Mena-Guacas et al. (2025), this phase, which is in line with agricultural teaching and learning methodologies, enhances contemporary practice and meets educational needs and outcomes. Furthermore, Kabato et al. (2025) emphasized changes to smart farming, which enhances the alignment of graduates with the current demands in industries. This innovation that has progressed from traditional to modern farms should be supported by the educational reforms in TVET colleges. However, the process is still hindered by a lack of modern tools, which are still expensive and difficult to handle, causing the nation to fall behind in technological progress. The practice of agricultural production is expected to be improved in the future by a variety of technologies. Operational competencies are therefore essential to maintaining the environment and continuing to produce more food. This approach improves productivity and ensures product quality in addition to developing operational competency skills (Getahun et al., 2024). Additionally, distinctive characteristics include protection from inclement weather, which could maximize agricultural output. Srinivasan and Yadav (2024) claim that there are too many elements in agricultural technology that support smart farming, such as soil moisture sensors for agricultural use and precision scheduling like smart irrigation. The necessity for TVET colleges to match their curricula with contemporary agricultural practices is highlighted by this action. In order to generate qualified graduates, TVET curricula should include modernized training where technology helps teaching and learning activities (Jellason, Robinson & Ogbaga, 2021).

To progress from traditional to smart agriculture, practice trials and agricultural training should continue to be technologically linked. This shift encourages students' and lecturers' interest and serves as a criterion for program excellence, indicating a readiness to advance and adapt (Sephokgole et al., 2023). In the long term, the TVET graduates might have the employable skills necessary to influence the agriculture sector and generate self-employment. According to Adebesin and Adelakun (2020), this indicates the need to enforce skills development, which becomes handy during the searching for or creating one. Possessing basic skills benefits graduates and maximizes their chances of being hired in the current labor market. Additionally, as part of the technology experimentation in the classroom, appropriate material may be discovered and practiced. This illustrates the advantages of technology integration since it now focuses on how technology is incorporated to enhance the teaching and learning process rather than just using technical tools. Bhattarai (2021) asserts that as theoretical knowledge is converted into learning material practicals, understanding how to incorporate technology into teaching and learning is crucial. This approach seeks to generate competitive graduates who are technologically proficient and capable of operating in the digital world employing agricultural new technologies, including artificial intelligence (AI), drones, and sensor systems, in accordance with TVET training objectives. Graduates are able to integrate into the contemporary technological environment because of their advanced agricultural technology skills (Magagula & Awodiji, 2024). A high employment rate and the ability to compete in a market can be fostered by this type of throughput rate.

Adoption of Technology Integration

Adoption of technology is a strategy to identify the suitable piece of technical equipment to utilize during teaching and learning agriculture. Stakeholders are encouraged by this trend to identify suitable technologies to improve educational operations, including the classroom setting (Zheng et al., 2024). Institutions, including TVET colleges, are not unique in this digital age, as educational activities are being conducted through technology integration. The primary goal of the teaching and learning workshops is to provide students with digital literacy so they can integrate into the AI-driven automotive industry (Magagula & Awodiji, 2024). This potential move presents benefits to TVET graduates to learn how to use technologies that exist in their labor market (Faloye & Faniran, 2023). One important tactic for skill development in TVET programs is digital competency. According to Seti, Ngqulana, and Sindesi (2025), the main motivation for the anticipated TVET institutions is to provide hands-on training in specialized areas and to guarantee that highly qualified graduates have outstanding employment possibilities in a variety of industries. Knowing how to adopt and use suitable technology helps to transform agriculture into a modern farming system (Chandra et al., 2024). Therefore, the TVET graduates will possess adventurous skills to fit into the labor market or to create employment for themselves.

The current offering of agricultural programs by TVET colleges shows a lack of suitable resources and equipment of a modern kind (Sephokgole et al., 2023). The knowledge of adopting the suitable resources is still hampered by financial challenges. Furthermore, traditional methods of farming that do not incorporate technology are no longer effective in addressing contemporary agricultural issues. The current students are blessed and presented with modern technologies, which are already adopted to be used in various activities, including educational activities and farming space (Sephokgole, 2025). Considering this situation, students have already possessed knowledge of utilizing some of the modern technologies that training in industries just finished off. This change is essential to engaging technology integration, as evidenced by the manner in which students complete learning tasks via online platforms. Students are exposed to the digital environment, which aligns with modern industries worldwide (Kalaman et al., 2023). Currently, to acquire employment skills, learning through the integration of technological equipment and tools, such as software and digital platforms, is crucial. Furthermore, technology-integrated training increases students' preparedness for the workforce and promotes the benefits of contemporary technology-based instruction (Zou et al., 2025). Rapid assessment is made possible by the integration of technology, which helps identify industries with high-quality capabilities.

Advanced Technology Integration

Advanced technology integration is the strategy that encourages the use of modern types of technologies. Therefore, TVE colleges ought to match this strategy by aligning their curricula to the current state of agriculture industry practices in the framework of 4IR (Seleke & Teis, 2025). This process is essential for bridging the skills gap and guaranteeing that graduates have the precise abilities needed to fit into sectors. If issues like inadequate infrastructure and a shortage of tools and resources are resolved, this can be accomplished (Denhere & Moloi, 2021). This would enable the lecturers to gain knowledge from experienced entrepreneurs and farmers who currently utilize technology to solve issues in agriculture. This will connect students with modern technologies already used in farming and further reform the acquisition of skills (Jarilkapovich, 2025). More specifically, students are motivated and have a feeling of belonging to agriculture when farming technology, such as software, sensors, data analysis, and stimulation platforms, is directly integrated into the workplace. In the ultimate analysis, students are improving their technical skills in a real-world workplace, and passive knowledge acquisition is converted into active practice.

RESEARCH METHOD

This study employed a mixed-method approach grounded in the pragmatic paradigm. According to the pragmatic paradigm, knowledge is derived from actions and ought to be used to address human issues in the real world. On the other hand, interpretivism is predicated on several realities, whereas positivism looks for a single, quantifiable reality (Teddlie & Tashakkori, 2009). The study identifies the pragmatism paradigm as appropriate for this study because it emphasizes workable solutions and results that can be put into practice. To gather information about selected TVET colleges, this study utilizes both quantitative and qualitative approaches. The following gradually outlines the structural workflow of the mixed-methods research approach:

a) Sampling and institutional sampling in selection:
   Targeted three carefully selected TVET colleges in the province of Limpopo that provide NATED and NC(V) agricultural programs.
b) Gathering quantitative data:
   Quantitative data was gathered through student questionnaires, and 482 student participants were given closed-ended questionnaires that were modified from Kotrlik et al. (2003) prior to class presentations.
c) Gathering qualitative data:
   Qualitative data was collected through a non-participant observation of three teaching lessons while taking field notes on actual classroom technology integration.
d) Validation of data:
   Peer review and member checking ensured content quality through expert peer evaluation and data dependability by verifying observation notes with pertinent lecturers.
e) Analysis of concurrent data:
   Analysis of Variance (ANOVA) on a 1-3 Likert scale was utilized to examine quantitative survey data, while thematic coding and ANOVA employed the Kotrlik-Redmann framework to qualitatively encode observation notes.
f) Triangulation and synthesis:
   The mixed-method analysis combined contextual depth with numerical breadth to validate the analysis of the levels of technological integration.

Participants

Drawing from my PhD research work, which concentrated on the three chosen TVET colleges in the Province of Limpopo that offered agricultural programs, led to this descriptive analysis. Purposive and convenient sampling were combined with concurrent mixed-method sampling in the study to produce knowledge about institutional problems (Teddlie & Yu, 2007). In addition to observing three teaching classes from the NC(V) and NATED programs, the study administered a questionnaire to 482 student participants. The purpose was to determine the correlation between a (NC(V)) and the level of technological integration in agricultural programs such as NATED. The participants were informed that their participation was entirely voluntary and that the information they submitted would remain anonymous (Creswell & Creswell, 2017).

Data Collection

A scheduled observation schedule and a closed-ended student questionnaire were the two main data collection tools used in this mixed-methods study through Kotrlik et al. (2003)'s four stages of technological integration. This model served as the theoretical framework for both instruments. The instruments accurately monitored the junction of technology integration into agricultural programs since the items and observation criteria were grounded in predetermined phases. To collect consistent, measurable data from a sample of 482 NATED and NC(V) agricultural students, a closed-ended student questionnaire was used to collect and record data. This tool evaluated technology access, training sufficiency, and student perceptions. The instrument was designed with a forced-choice style that included categorical checkboxes and a 3-point Likert scale to reduce respondent fatigue and prevent data input errors. The researcher was able to assess real classroom and laboratory activities without interfering with instruction delivery by using an organized non-participant observation schedule as an objective, contextual counterweight to the self-reported surveys. During active agriculture sessions, the researcher took on a passive position and methodically documented pedagogical practices and physical infrastructure as they happened.

A group of specialists in educational technology and TVET lecturers examined the proposed instruments to ensure face validity and substance. This procedure confirmed that the items sufficiently spanned the range from fundamental classroom ICT to modern agricultural tools, and the terminology was suitable for both NATED and NC(V) curricula. Furthermore, the indicators' accuracy in measuring Kotrlik's four integration stages within the TVET college environment was confirmed by an expert peer review. The combination of the qualitative observation schedule and the quantitative questionnaire improved construct validity. The self-reported infrastructural problems gathered from the student surveys were cross-verified by looking at the actual use of modern agricultural tools at TVET college facilities. A planned, sequential procedure was used for data collecting. Prior to class presentations, students first filled out the questionnaire in person. The researcher and TVET lecturers in the classroom worked together to facilitate the procedure to optimize response rates and guarantee quality control. The researcher performed the non-participant observations after the survey. The observation schedule/checklist relied on rigorous operational descriptions that distinguished between modern agricultural tools and basic classroom ICT in order to prevent observer bias and preserve uniformity across the three chosen TVET college sites. Lastly, the researcher used member checking to make sure that the descriptive field notes were reliable. This involved discussing important findings with the lecturer after the class to make sure the records appropriately represented the classroom setting (Morrow, 2005).

Data Analysis

A Likert scale ranging from 1 to 3 was used to code the students' answers into numerical spreadsheets. Data was analyzed using Analysis of Variance (ANOVA) to verify the variable associations of programs from the quantitative data (Mouritsen et al., 2016). Observation data was simultaneously collected to determine the persistent components that impeded technology integration in agricultural programs. Both quantitative and observational data were analyzed to determine the levels of technology integration through the triangulation process.

Ethical Consideration

Throughout the research process, this study closely followed established ethical norms and protocols to protect participants and maintain institutional standards (Creswell & Creswell, 2017). The Department of Higher Education and Training and the relevant TVET campus management issued gatekeeper permissions to access the teaching and learning spaces after the Research Ethical Committee at Tshwane University of Technology issued formal ethical clearance. The researcher gave participants consent forms to complete as a sign of voluntary participation and to give consent for utilizing audio- or video-recording tools during observations prior to data collection. To ensure an ethical and convenient data collection process goes well, observation scheduled sessions was convenience and survey respondents proactively requested questionnaires which resemble voluntary and devoid of force or fraud. All information gathered was restricted to the researcher alone to ensure complete anonymity and confidentiality. The identity of each participant and the participating colleges were hidden using unique pseudonyms.

RESULTS AND DISCUSSION

Result

To address the concern about how TVET colleges' agricultural programs are evolving toward technology-enhanced learning, the questionnaire findings and observations were analyzed. After presenting the students' biographical information, the questionnaire responses and their association to the research variable were examined. As stated earlier, four stages from Kotrlik-Redmann's (2003) served as a framework for this study.

Students' Biographical Data

A highly specialized and unique approach to technology integration is required due to the demographics of TVET agriculture students in Limpopo. The study, which has a 59% female majority, questions established gender digital inequalities by arguing that modern agricultural tools, such as drones and automated analytics, can empower young women by removing physical hurdles in farming. Additionally, youth (91% flanked by their ranging from 20 to 30), nearly all-African population verifies "digital native" readiness, but in practice, they require low-bandwidth, mobile-first platforms that are adapted to local rural contexts rather than imported Western models. Lastly, the curricular division necessitates customized resource allocation in simple, theory-focused digital resources for NATED students, and useful, sensor-based workshop tools exist in the NC(V) program.

Table 1. The students' biographical data

Variable	Description	Frequency	Percentage (%)
Gender	Females	284	59
	Males	198	41
	Total	482	100
Age	16-19	29	6
	20-30	441	91
	Other	11	2
	Unknown	1	0.2
	Total	482	100
Race	African	481	99.79
	Other	1	0.21
	Total	482	100
Program	NATED	169	35
	NC(V)	313	65

Variable	Description	Frequency	Percentage (%)
	Total	482	100

The biographical profile of TVET agricultural students in Limpopo displays a striking distinction in which structural and socioeconomic limitations counteract individual readiness. Although the young, mostly Black African population supports "digital native" theories, their marginalized backgrounds (Muzite & Gasa, 2024) demonstrate that cognitive willingness does not equate to structural capability, completely shifting the adoption bottleneck away from student resistance and toward institutional deficiencies. As a result, social justice must be incorporated into technology acceptance frameworks, which forces TVET colleges to make investments in zero-rated platforms, offline learning management systems, and on-campus digital hubs that support environments with limited resources. Lastly, the curriculum architecture necessitates a divided strategy that offers high-efficiency academic tools like e-textbooks to support the condensed, semester-based schedule of the 35% NATED minority and engaging, sensor-based agriculture tools for the 65% NC(V) practical majority.

Table 2. The exploration of technology integration by program association

Exploration of technology integration			Program: NATED	Program: NC(V)	Total	Pearson Chi-Square	p-value
2.1 We experience challenges when technology is used during teaching and learning.	Agree	Count	88	207	295		
		% within program	52%	67%	62%	17.477a	0,00016
	Not sure	Count	25	15	40		
		% within program	15%	5%	8%		
	Disagree	Count	55	88	143		
		% within program	33%	28%	30%		
Total		Count	168	310	478		
2.2 Innovative agricultural technologies are used in teaching and learning.	Agree	Count	88	126	214		
		% within program	54%	41%	45%	12.545a	0,001887
	Not sure	Count	41	70	111		
		% within program	25%	23%	24%		
	Disagree	Count	34	112	146		
		% within program	21%	36%	31%		
Total		Count	163	308	471		
2.3 The use of innovative technologies improves our understanding of what we learn.	Agree	Count	138	234	372		
		% within program	88%	78%	81%	7.789a	0,020353
	Not sure	Count	13	37	50		
		% within program	8%	12%	11%		
	Disagree	Count	6	30	36		
		% within program	4%	10%	8%		
Total		Count	157	301	458		

A substantial percentage of students in NC(V) (67%) and NATED (52%) report having challenges when learning and teaching. The NC(V) stream's curriculum, which is intended to be more practically oriented, appears to suffer greatly when infrastructure fails, as evidenced by the much higher friction in this stream. A systemic problem is highlighted by observations of modems running out of data and unexpected network outages. The work of Sephokgole, Makgato, and Khoza (2024), who contend that outdated equipment and network disconnections significantly impede TVET growth, is directly supported by this. It also emphasizes a recurring fact in TVET colleges in South Africa that without reliable basic resources, technology cannot thrive. Although 41% of NC(V) students and 54% of NATED students concur that "innovative" technologies are deployed, observations show a difference. Instead of specialist agriculture education, the "innovative tools" are frequently just standard communication platforms like Google Forms, Microsoft Teams, or WhatsApp utilized for administrative work. Despite these challenges, a significant 78% of NC(V) students and 88% of NATED students concur that technology enhances their understanding. The educational theories emphasized by Sephokgole, Makgato, and Khoza (2023) align with this broad consensus. Deconstructing theoretical concepts through the use of projectors and screens to illustrate complicated occurrences, such as plant diseases, transforms passive listening into powerful, visual learning.

Table 3. The experimentation with technology integration by program association

Exploration of technology integration			Program: NATED	Program: NC(V)	Total	Pearson Chi-Square	p-value
3.1 Technologies are currently being used to practice agriculture successfully.	Agree	Count	122	187	309		
		% within program	75%	62%	66%	8.423a	0,014825
	Not sure	Count	21	51	72		
		% within program	13%	17%	15%		
	Disagree	Count	20	64	84		
		% within program	12%	21%	18%		
	Total	Count	163	302	465		
3.2 Agriculture lecturers use advanced technological tools frequently when training students.	Agree	Count	82	140	222		
		% within program	50%	46%	48%	12.800a	0,001662
	Not sure	Count	30	26	56		
		% within program	18%	9%	12%		
	Disagree	Count	53	136	189		
		% within program	32%	45%	40%		
	Total	Count	165	302	467		
3.3 Innovative technologies are used during agriculture practicals.	Agree	Count	85	135	220		
		% within program	52%	44%	46%	6.738a	0,034425
	Not sure	Count	49	83	132		
		% within program	30%	27%	28%		
	Disagree	Count	31	92	123		
		% within program	19%	30%	26%		
	Total	Count	165	310	475		

Compared to NC(V) students (62%), NATED students are more certain (75%) that technology is being successfully applied in agriculture. This variation results from the fact that "technology" in TVET classes is frequently restricted to simple multimedia tools (speakers, projectors) utilized for lecture delivery rather than true smart agricultural hardware. Less than half of NC(V) students (46%) believe lecturers routinely employ advanced tools, compared to half of NATED students (50%). Actually, 45% of NC(V) students expressly disagree. According to Jellason, Robinson, and Ogbaga (2021), digital literacy and focused resource management are essential to modern agriculture. The training is still lacking if lecturers merely use laptops to display images of animal illnesses instead of teaching students how to use real agricultural software or precision instruments. There is a sharp increase in disagreement (19% for NATED, 30% for NC(V)) when asked if novel technologies are used during agriculture practicals. A crucial gap in Sephokgole, Makgato, and Khoza's (2023) model for effective agricultural education is the transition from basic technology acquisition (purchasing a projector) to effective application (using data-driven farming instruments in the field).

Table 4. The adoption of technology integration by program association

Exploration of technology integration			Program		Total	Pearson Chi-Square	p-value
			NATED	NC(V)			
4.1 Integrating technologies helps to acquire the knowledge and skills needed in the agriculture sector.	Agree	Count	144	257	401		
		% within program	88%	83%	85%	9.958a	0,006881
	Not sure	Count	20	34	54		
		% within program	12%	11%	11%		
	Disagree	Count	0	18	18		
		% within program	0%	6%	4%		
	Total	Count	164	309	473		
4.2 No suitable integration technologies are used in the practice of agriculture.	Agree	Count	43	100	143		
		% within program	26%	33%	31%	7.620a	0,022153
	Not sure	Count	86	117	203		
		% within program	52%	39%	44%		
	Disagree	Count	35	82	117		
		% within program	21%	27%	25%		
	Total	Count	164	299	463		
4.3 We complete tasks with the help of technology and submit them electronically.	Agree	Count	84	127	211		
		% within program	52%	42%	45%	6.478a	0,039203
	Not sure	Count	21	34	55		
		% within program	13%	11%	12%		
	Disagree	Count	57	145	202		
		% within program	35%	47%	43%		
	Total	Count	162	306	468		

They are aware of how the industry is evolving. TVET colleges are required to offer skills that are immediately adaptable to changing economic sectors, as noted by Maponya and Mpandeli (2021). Graduates will be unprepared for the data-driven agriculture industry if TVET colleges do not incorporate digital literacy. The majority of students (52% NATED, 39% NC(V)) are proven to be unaware about whether the current technology is actually appropriate for agricultural use or not. This ambiguity arises from the replacement of specialist agriculture technology with general technologies like Teams and WhatsApp. This is similar to the cautions made by Sephokgole, Makgato, and Khoza (2024), that students do not recognize the immediate professional significance of technology when it is viewed as an optional "add-on" rather than an essential component of the agricultural curriculum. When it comes to electronic assignment submission, there is a clear difference that 52% of NATED students successfully complete their work and submit online, while 47% of NC(V) students expressly disagree. This demonstrates that NATED has outperformed NC (V) in digitalizing its official administrative procedures. Instead of being integrated into the official academic process, technology for NC(V) is still limited to rapid information collecting. The contemporary, data-driven strategies suggested by Maponya and Mpandeli (2021) do not align with this approach.

Table 5. The advanced technology integration by program association

Exploration of technology integration			Program		Total	Pearson Chi-Square	p-value
			NATED	NC(V)			
5.1 I become more skilled when there is an advanced integration of technologies in teaching and learning.	Agree	Count	141	228	369		
		% within program	85%	74%	78%	9.674a	0,00793
	Not sure	Count	17	46	63		
		% within program	10%	15%	13%		
	Disagree	Count	7	35	42		
		% within program	4%	11%	9%		
Total		Count	165	309	474		
5.2 I am gaining experience in addressing real technological problems associated with agricultural production.	Agree	Count	127	203	330		
		% within program	77%	66%	70%	7.053a	0,029406
	Not sure	Count	26	58	84		
		% within program	16%	19%	18%		
	Disagree	Count	13	47	60		
		% within program	8%	15%	13%		
Total		Count	166	308	474		
5.3 Technical changes enhance performance in training programs.	Agree	Count	134	219	353		
		% within program	81%	71%	74%	7.667a	0,021633
	Not sure	Count	19	67	86		
		% within program	11%	22%	18%		
	Disagree	Count	13	24	37		
		% within program	8%	8%	8%		
Total		Count	166	310	476		

Students (85% NATED, 74% NC(V)) are adamant that advanced integration improves their skills. A significant portion of students (77% NATED, 66% NC(V)) believe they are learning how to solve real-world agricultural production problems. The gap between textbook descriptions and actual farm management is filled in part by the use of interactive gadgets like touch displays. This supports the conclusions of Seti, Ngqulana, and Sindesi (2025), who found that because sophisticated technology integration replicates real-world work contexts, it is essential for modernizing TVET education. Lastly, 71% of NC(V) students and 81% of NATED students concur that technological advancements enhance their academic achievement. Students naturally utilize tablets and smartphones to communicate instructional content via WhatsApp after school hours. High levels of student involvement are demonstrated by this proactive action. It supports

Li's (2024) findings that TVET colleges can effectively close the gap between traditional methods of teaching and modern industry demands by modernizing infrastructure and formalizing these digital habits into the curriculum. The data clearly shows that students in both streams are very driven and understand the need for digital literacy for modern agriculture. However, compared to the NC(V) program, the NATED program now has greater satisfaction percentages and a more seamless deployment. TVET colleges must stop using simple multimedia tools (such as projectors and WhatsApp) for broad communication in order to completely close this gap. Instead, they must concentrate on building a reliable data infrastructure and implementing specialized, practical agricultural technology.

CONCLUSION

This study found a considerable association amongst the NATED and NC(V) programs. Although most students in both fields are aware that modern technology can enhance theoretical learning and professional skills, there is still a noticeable "digital divide." At the moment, the majority of TVET colleges just employ projectors in the classroom and simple communication apps like WhatsApp and Microsoft Teams. Technolocal tools are used for communication purposes for driving agricultural content. The primary relevance of the findings is that, despite high student interest, systematic infrastructural flaws are impeding the evolutionary imperative of agriculture trainings. Additionally, the lack of specialized equipment and the frequency of network disruptions hinder digital transition. The TVET colleges must channel the integration of technology into teaching and learning resources. Therefore, a strong technical infrastructure should be prioritized in order to guarantee connectivity, and lecturers are trained to transition from basic to modern training. If these modifications are made practicable, the curriculum will continue and be improved to the highest level. Therefore, it is essential to take innervations' dedication and efforts into account in order to offer the TVET industry a sense of achievement. Instead of only emphasizing theoretical agricultural concepts or fundamental computer literacy, the Department of Higher Education and Training (DHET) must immediately update the agricultural curricula to explicitly incorporate contemporary, market-oriented tools into the module outputs. Although this study recommends using the current framework, further research may look at the precise effects of digital literacy and precision tool training on the career prospects of agricultural graduates. The final component of the strategy is to make sure that TVET colleges in South Africa produce a future generation of modern industry professionals who are interested in how these skills translate into job prospects in the digital economy. Because this study was limited to particular Technical and Vocational Education and Training (TVET) programs, the findings might not accurately represent the particular infrastructure challenges or rates of technological adoption faced by TVET colleges in other South African provinces or rural areas. In order to measure tangible changes in students' academic performance and practical skills over time, future studies should use a longitudinal study design to observe TVET institutions both before and after they receive specialized precision agriculture technologies or infrastructure enhancements.

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