

African Journal of Development Studies (AJDS)

Published consistently since 2012
ISSN 2634-3630 E-ISSN 2634-3649

Indexed by IBSS, EBSCO, ERIH PLUS, COPERNICUS, ProQuest,
SABINET and J-Gate.

Volume 16, Number 2, June 2026
pp 5-29

Academic Outputs from South Africa's Clothing, Textiles, Leather, and Footwear Technology Station

DOI: <https://doi.org/10.31920/2634-3649/2026/v16n2a1>

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Abstract

The South African fashion industry and its associated innovation activities generate a limited amount of new knowledge. This paper narrows this gap by exploring traditional academic outputs arising from the technology station, with a focus on the clothing, textiles, leather, and footwear (CTLF) industry. Using Kruss and Visser's determinants for traditional academic outputs, the paper conducted interviews (n=3) with relevant stakeholders and analysed documents (n=22). Thematic analysis revealed that the technology station produces satisfactory traditional academic outputs for the CTLF industry to increase innovation, competitive advantage, and contribute to the SDGs. Sharing and spreading new knowledge is among the major challenges for traditional academic outputs from the technology station. The technology station could increase its

contribution to innovation competitive advantage and SDGs by improving the rate of diffusing new knowledge. This paper contributes to the modest but expanding body of literature regarding national systems of innovation within the specific context of the South African CTLF industry.

Keywords: Clothing and textile industry, Technology station, Product development, Competitive advantage, SGD, System of Innovation

Introduction

The Technology Innovation Agency (TIA) operates in the Department of Science and Innovation (DSI) and carries out various legislative and policy mandates, strategic focus, and performance measurement. The TIA focuses on the following priorities: bioeconomy strategy, technology stations programme, and commercialisation (TIA, 2019). By advancing the three areas, TIA aligns with broader national government socioeconomic imperatives of poverty, inequality, and unemployment (DST, 2018a; National Planning Commission, 2012). These imperatives are also true for the African Union Agenda 2063 and United Nations SDGs 2030 (African Union Commission, 2022). The technology station programme is discussed further below.

The Technology Stations Programme (TSP) is a system where higher education institutions (HEIs), mainly universities of technology (UoTs), establish a center to distribute their knowledge to the industry by solving industry problems (DTI, 2016). Currently, 18 technology stations are geographically distributed across South Africa, with respective sectoral focus areas (DTI, 2018). The technology stations offer services from the prototyping/piloting stage to pre-commercialisation (TIA, 2019).

Few studies exist that measure the contribution of TIA's 18 technology stations. This underscores the gaps that this article attempts to address. Only one technology station is dedicated to the clothing and textiles industry (DST, 2018a). This article makes a significant contribution to the evolving body of literature regarding the Technology Station Clothing and Textiles (TSCT) and technology stations more broadly. The existing literature indicates that the clothing and textiles industry suffers from a low rate of innovation, a matter that requires urgent attention (Mbatha, 2018). Mbatha (2022) posits that it is important to conduct research on clothing and textiles-related studies due to their importance for the Industrial Policy Action Plan (DTI, 2018) in contributing to the

triple challenge of poverty, inequality, and unemployment (South African Department of the Presidency, 2011). In line with the above, this paper seeks to understand how traditional academic outputs are produced and what challenges and opportunities exist in the technology station.

This article is useful for understanding the sectoral systems of innovation from the technology station's context, thus building on Mbatha and Mastamet-Mason (2023). Given the strategic importance of the clothing and textiles industry to SDGs and the AU agenda (Sihlobo & Mbatha, 2021), this article is also useful to the development of literature on the contribution of technology stations toward the SDGs and the AU Agenda 2063.

Literature Review

Overview of traditional academic outputs

Outputs are short-term benefits commonly used through the input-process-output (IPO) model (Bushnell, 1990). Outputs are effectiveness indicators, specifically quality, performance, and perceptions of satisfaction (Psychology Research and Reference, 2020). The study used Kruss and Visser's (2017) traditional academic outputs. In the context of this study, traditional academic dimensions include academic publications, dissertations and theses, academic collaborations, policy documents and reports, scientific discoveries, and graduates with relevant skills (Kruss & Visser, 2017).

There are 26 public HEIs in South Africa (DHET, 2018), and 14 have clothing and textiles-related departments (Sihlobo & Mbatha, 2022). These HEIs have degree or diploma programmes with disciplines in fashion, consumer science, textiles, and clothing management (Sihlobo & Mbatha, 2022). Kruss and Visser (2017) state that public HEIs were established in diverse periods to meet specific economic and political purposes. Etzkowitz (2008) shows that HEIs should also be entrepreneurial universities, thus playing a stronger role in the socioeconomic development space. Thus, the various HEIs shaped their differential and unequal nature as 'reputationally controlled work organisations'. The traditional academic outputs are outlined below, followed by a presentation of the research questions.

Academic publication output

Academic publications are scholarly research published in conference proceedings, journal articles, books, and book chapters (Kruss & Visser, 2017). It is generally expected that HEI staff serve as the main drivers of academic publications, while student involvement in publishing remains more limited. It is because part of the HEI staff's job description is to contribute to the HEI through research, and therefore, HEI academics are researchers (HSRC-CeSTII, 2019). Madue (2011) states that South Africa created a research funding framework policy to encourage productivity by rewarding high-quality research output at public universities. The framework does not measure all output but recognises the significant types of research output produced by universities and uses commissions to determine the quality of outputs (DHET, 2018). The rewarding of quality research output at public HEIs forms the basis for sustaining current R&D and promoting increased productivity of R&D (DHET, 2018).

Academic publications in the clothing and textiles industry are negatively affected by the low number of academic staff with doctorates (7%), as illustrated by Figure 1.

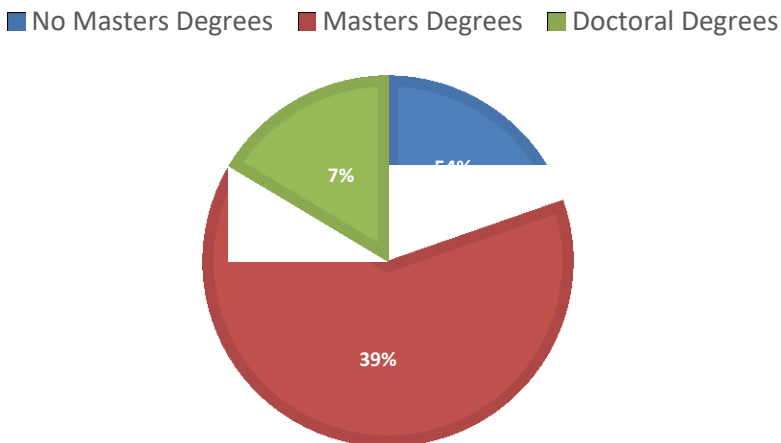


Figure 1: Academic staff qualifications in fashion design departments (Mbatha, 2017)

Figure 2 demonstrates that the academic staff with doctorates has increased within five years (16%), demonstrating that there may be an improvement in competitive advantage and innovation in the clothing and textiles of South Africa.

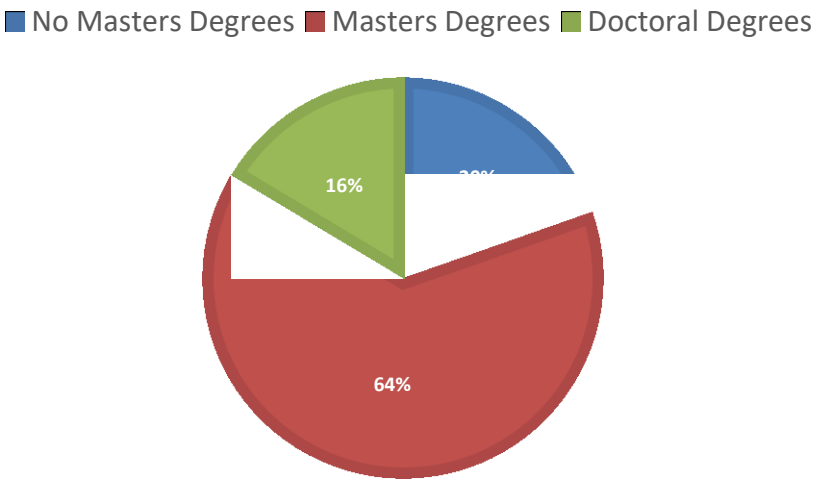


Figure 2: Academic staff qualifications in fashion design departments (Mbatha, 2022a)

It is clear from Figure 3 that academic publications are on the rise in HEIs, with clothing and textiles-related HEIs. Given the rise in academic staff holding doctorates over the five years illustrated in Figure 2, it can be argued that scholars within clothing and textiles disciplines contributed to the overall growth in academic publications.

Figure 3 documents increased academic publications from HEIs with fashion design departments.

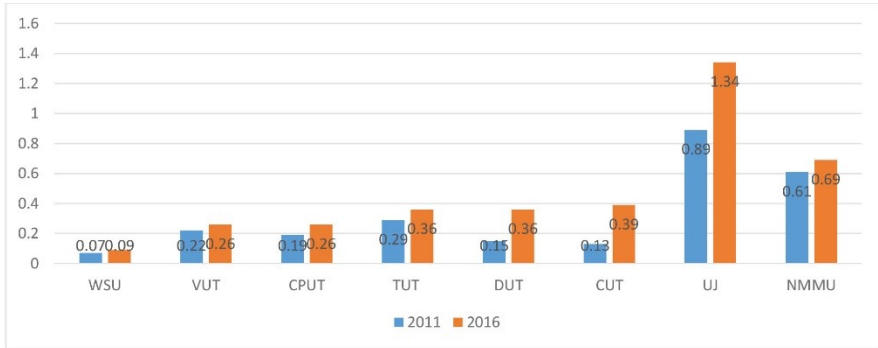


Figure 3: Academic publication output units per capita (CHE, 2018: 98)
While the volume of publications is rising, the extent to which this scholarly output translates into enhanced innovation within the clothing and textiles sector remains unclear. Studies are required to understand if this increase in academic publications and academic staff qualifications translates into increased innovation and competitive advantage for clothing and textiles.

Dissertation and thesis output

A dissertation or thesis is a document submitted in fulfilment of an academic degree (master's and doctorate), presenting the author's research and findings (University of KwaZulu-Natal, 2019). Master's graduates should be able to demonstrate specialist knowledge to enable engagement with and critique current research or practices (SAQA, 2012). Doctoral graduates should be able to create critical, new knowledge and demonstrate expertise in an area at the forefront of a field, discipline, or practice (SAQA, 2012).

South Africa has the goal of 75% of academic staff possessing doctorate qualifications by 2030 (National Planning Commission, 2012). Figure II indicates that academic staff in the clothing and textiles disciplines positively contributed to the NDP Vision 2023 goal through the increase. Figure I underscores a 25% increase in academic staff who completed their theses to have master's degrees. This highlights that there has been an increase in thesis output. However, due to the low rates of postgraduate enrolment and graduation in South Africa, the output has not been as great as anticipated (DHET, 2018). In the context of the clothing and textiles discipline, Sihlobo and Mbatha (2022) found that 79%

of academic staff did not participate in forms of university-industry-government research and development (UIG R&D) collaborations, while 71% held a master's qualification or higher. This underscores concerns regarding the overall effectiveness of both higher education and doctoral training programmes (Frick et al. 2017).

Academic collaborations' output

Academic collaboration is a joint venture by researchers of differing stature, funding status, or types of organisations (OECD, 1997). The HSRC-CeSTII (2019) states that HEIs are critical to R&D and innovation because the fourth industrial revolution (4IR) is a collaborative endeavour that requires all actors to collaborate (university, industry, government, and social partners). This is supported by Porter (1990), as he argues that if a sector has sophisticated research institutions, that sector tends to have developed a competitive advantage from research that grounds its innovation.

Mbatha has pioneered studies in science and technology collaborations in the CTLF industry that are growing. He argued that research into collaborations within the clothing and textiles industry is essential for understanding the pace of innovation (Mbatha, 2014). HEIs with clothing and textiles disciplines did not have research institutions that focus on sophisticated disciplines. Thus, the rate of collaborations may be low (Mbatha & Mastamet-Mason, 2018). Mbatha and Mastamet-Mason (2021) found that university and industry play a weaker role while government plays a stronger role in sectoral systems of innovation for the clothing and textiles industry. These findings were corroborated by Mbatha (2022). Sihlobo and Mbatha (2022) found that academic collaborations with institutions like the TSCT were low among clothing-related academic staff. While this is the case, limited studies exist that highlight the role played by the TSCT on traditional academic output, as envisaged by Kruss and Visser (2017). This gap makes it important to look at whether the TSCT is helping improve collaboration.

Scientific discoveries output

Scientific discovery is defined as an invention or innovation derived from new or enhanced technologies, resulting in products or processes generated through productive scientific inquiry (Schickor, 2018). The

National Intellectual Property Management Office (NIPMO, 2017) suggests skills for success in scientific inquiry. These include a technical background in science and engineering, an understanding of the stages of R&D of technologies, and intellectual property (IP) protection. The office also suggests the ability to market and develop commercial relationships with local and international partners. Figure 4 demonstrates scientific discoveries in the clothing and textiles industry. The existing literature provides detailed accounts of scientific discoveries within the specific context of the clothing and textiles discipline. Mbatha (2020) indicates that Ramatla developed a Braille price and information tag to assist the visually impaired in shopping for their clothes independently.

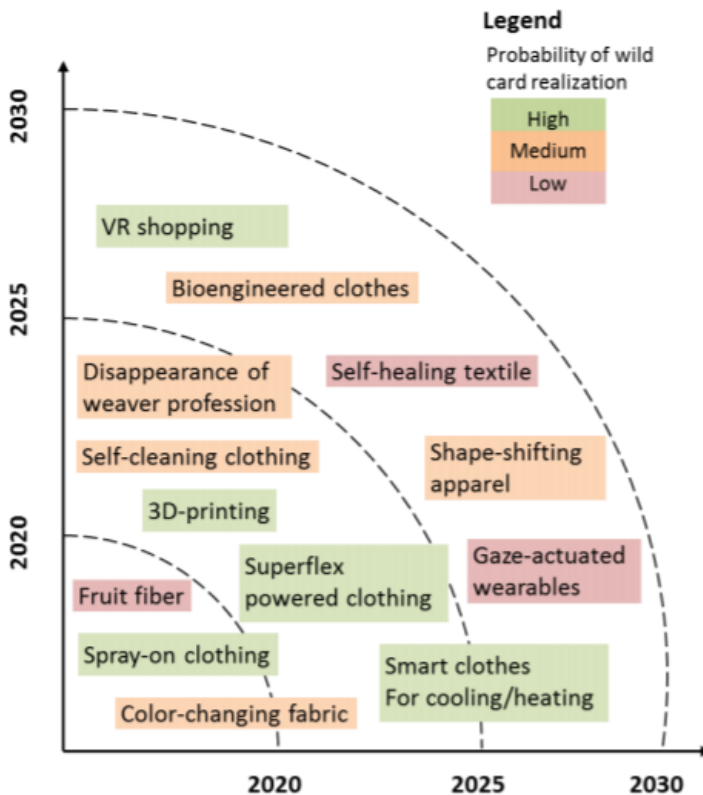


Figure 4: The future of scientific discoveries of the clothing and textiles industry (Milshina et al., 2019:20)

Mbatha and Mastamet-Mason (2021) show that an eco-friendly yarn was invented using a mechanically modified waste flex, an orthopaedic shoe

invention is in its final stages, and the development of a filtration pipe to treat water from the textile dye factories was developed. All of these scientific discoveries were the result of research conducted by academics across various clothing-focused departments in HEIs. This underscores that while the rate of innovation has been low (Molekwa et al., 2021), there are improvements. While discoveries exist, the challenge is turning them into products that benefit society.

Graduates with relevant skills output

A graduate with relevant skills is a student who can transfer skills learned from an academic degree to the workplace environment and has the competitive skills necessary for the industry (HSRC-CeSTII, 2019). Top-ranked attributes in South Africa for entry-level professions include a passion for the profession, trainability, willingness to learn, and communication skills (Schreck et al., 2020). However, South African graduates struggle to get into entry-level jobs due to the continual increase in the unemployment rate of graduates in the country (Schreck et al., 2020). Moreover, these four areas significantly enhance the employability of clothing and textiles graduates: technical competencies, life skills for a globalised knowledge economy, higher-order cognitive skills, and metacognitive strategies (Jacobs, 2018).

The discussion about graduates with relevant skills is ongoing in the context of the clothing and textiles industry. Mbatha and Mastamet-Mason (2015) argue that the industry has an under-skilled workforce unable to take over from ageing managers. Molekwa et al. (2021) observe that persistent challenges regarding skills development remain prevalent at the graduate level. The collaboration and policy cohesion between the clothing and textiles actors have been weak in supporting the development of graduates with relevant skills (Mbatha & Mastamet-Mason, 2023). Further studies like this paper are required to understand if the TSCT does produce graduates with relevant skills.

Methods

A qualitative study (Clark & Creswell, 2015) used a case study research design to examine the traditional academic output. Document analysis (Zeegers & Barron, 2015) was used to systematically evaluate documents (n=23) to increase understanding of traditional academic output in the

TSCT. Interviews consisting of managers (n=3) from TIA and TSCT were conducted via videoconferencing since it was during the COVID-19 pandemic. The Windows-based ATLAS.ti computer-aided qualitative data analysis software (CAQDAS) was used to support the data analysis (Frieze, 2012). The study adhered to various participant ethics, including confidentiality, informed consent, and voluntary participation (Joe et al., 2017). The host university granted ethical approval with ethical clearance.

The apparent relationships were between the university and the government because the researcher spoke to people representing these spheres. However, the industry relations were based on the interviewers' perceptions and not on industry personnel. The TIA is a state-owned enterprise, meaning the government has control. The TSCT operates in a public university of technology. The study only included employees connected to government organisations. The study left out the clothing and textiles industry personnel, and therefore, the research cannot be generalised to the clothing and textiles industry personnel of South Africa.

Findings

This paper presents its findings by utilising the framework of Kruss and Visser (2017) regarding the dimensions of traditional academic outputs. Data from documents will be indicated using (*Doc*), and data from interviews will be indicated using (*Int*).

Academic publication outputs

The findings indicate that the number of academic publication outputs produced through the TSCT is increasing. Findings show that the TSCT employed new technology and technical research in their recent academic publication outputs. Document analysis stated that the '*Paper, titled Ultrasonic welding – Innovative joining technology for sports technology application*' **Doc**. A respondent corroborated this by highlighting that '*the most recent publication looked at harmful substances in clothing and textiles... we selected baby clothing from various retailers, analysed them and checked for harmful chemicals in the type of product*' **Int**. These findings indicate an increase in applied and technical research from the TSCT. These findings show that the TSCT produces academic publication outputs that contribute to the National Development Plan (NDP), Sustainable Development Goals (SDGs), and African Union Agenda 2063.

The findings highlight challenges affecting academic publication outputs. The TSCT has been unable to diffuse research projects before publication. The TSCT focused more heavily on scholarly dissemination through publications than on the actual implementation or transfer of its research finding. The respondent puts it that *'A lot of researchers rushed to present their findings at conferences or to publish papers'* **Int.** This finding underscores that the TSCT published knowledge to the clothing and textiles sector through public channels, which may offer diminished competitive value as the information is openly accessible. The finding suggests that once a publication is made, research results are not explored further to address the community's needs. This underscores the challenges of the TSCT's academic publication outputs.

The findings show that the TSCT has an opportunity to deepen its academic publication outputs. The findings show that the TSCT is finalising an implementation plan to have their own master and doctoral programmes. The TSCT could produce more academic publication outputs, given the advanced skills found through document analysis *'Heading up research activities in the field of technical/smart textiles... has held an NRF C2 rating since 2015'* **Doc.** The findings indicate that the TSCT could increase academic publication output that addresses community needs and improves commercialisation. A respondent posits that *'Three researchers with PhDs in our department, doing more applied research in industry. Not to deliver publications but to find a solution to a particular problem in the industry'* **Int.** The findings highlight that the TSCT acknowledges that it has an opportunity to increase its contribution to the NDP, SDGs, and African Union Agenda 2063. The TSCT has the opportunity to capitalise on research and development investments by enhancing the quality of its partnerships, thereby increasing its overall contribution to economic growth. The findings from the dissertations and these outputs are presented in the next section.

Dissertations and thesis outputs

The findings indicated that the TSCT does not offer master and doctoral qualifications. The TSCT engages in master dissertation outputs through collaborating with clothing- and textiles-related academic departments. The findings indicated that the TSCT produces dissertation outputs as narrated by the respondent, *'A master's qualification looking at workwear for women using the facilities of the TSCT, the 3D body scanner to develop better fitting*

workwear for women' **Int.** This is supported by the document analysis, indicating that *'Exploration of ultrasonic welding, which forms part of a student master's dissertation'* **Doc.** These findings show that TSCT contributes to dissertation outputs. Document analysis revealed that *German Agency for Technical Cooperation (GTZ) and TLA funded the TSCT's hosting of a visiting of academic... to supervise four MTech students'* **Doc.** The findings show that international expertise is available for dissertation output through TSCT collaborations. The above findings show that the TSCT is engaged in research in sophisticated disciplines (3D body scanning and ultrasonic welding), applies sophisticated technology, and employs advanced skills for supervision, thus increasing the quality of research done in these dissertations. The findings further show that there is no empirical evidence to confirm the production of theses by the TSCT.

The findings indicate that the TSCT does have dissertation and thesis challenges affecting its throughput and supervision rate. It is believed that once dissertations are completed, they are diffused to improve the clothing and textile industries. A respondent presented these challenges in this manner: *'A lot of people do studies, but they are not being applied'* **Int.** This underscores that the rate of innovation is negatively affected by the inability to diffuse research. The findings show that the TSCT is in the process of establishing master's and doctoral qualifications that will be housed in the TSCT. Through document analysis, the TSCT details that *'Our access to top-rated research, postgraduate students, industry experts and the latest equipment means that you have a complete knowledge-generating hub at your disposal'* **Int.** The above stakeholders represent vital actors in the establishment of a research institution focused on specialised disciplines, designed to produce postgraduate students with advanced expertise. Academic collaboration findings are presented as follows.

Academic collaboration outputs

The findings showed that academic collaboration outputs in the TSCT were a mixture of collaborations with universities, companies, SMEs, and other institutions throughout the years. The findings show that the TSCT does establish collaborations with other technology-related institutions with engineering capabilities to support their clothing and textiles research objectives. Document analysis details that *'A collaborative project was completed with the Advanced Manufacturing Technology Laboratory (AMTL) to develop engineering solutions for the clothing and textile industry'* **Doc.** These findings

underscore the role played by TSCT to increase the rate of innovation and improve competitive advantage in the clothing and textiles industry of South Africa by drawing on expertise and resources outside of the TSCT and the clothing and textiles industry. The findings indicate that the TSCT engages in academic partnerships aimed at fostering the informal sector, thereby contributing to regional socioeconomic development. Document analysis indicated that *'With the City of Cape Town, we particularly work with them, assisting them with the development of the informal sector'* **Doc**.

Through this collaboration, the TSCT plays a role in transforming the informal sector. The findings show that challenges of academic collaborations relate to bureaucracy, trade secrets, and meeting compliance requirements. As indicated above, the TSCT has international, national, and regional academic collaboration actors as a result. The TSCT faces the difficulty of tailoring its documentation to meet the specific reporting and operational guidelines required by each of its various actors. A respondent put it this way, *'We, unfortunately, have to tailor-make reporting to different people'* **Int**. This is a challenge because it is a time-consuming exercise that the TSCT continues to perform for its actors in academic collaborations. The findings show that access to the clothing and textiles industry information is a challenge that affects academic collaborations. The clothing and textiles industry firms hold back in sharing information that may influence their competitive advantage during academic collaboration with the TSCT. A respondent expressed it in this way, *'Sometimes they [industry] share, sometimes they don't... they also see it as their competitive advantage'* **Int**. This limits the impact the TSCT may have in academic collaborations and improving competitive advantage for the clothing and textiles industry.

A respondent stresses the challenges of understanding management and government compliance requirements. This was expressed in this manner by the respondent, *'Partners are inadequately capacitated to effectively achieve desired goals and objectives, as well as the required governance and management compliance standards'* **Int**. Challenges in managing collaboration goals, objectives, and governance issues may negatively affect the effectiveness of academic collaborations in which TSCT is involved. It is believed that the academic collaboration environment is not conducive to optimising the R&D returns for TSCT and its actors. This was stated by the respondent as follows: *'a better enabling environment for the exploitation of R&D outputs of HEIs in partnership with other government agencies and entities.'* **Int**. These findings show that the TSCT acknowledges it has

yet to fully investigate or leverage the outputs resulting from its collaborations with various actors.

Scientific discoveries

The findings show that scientific discoveries from TSCT are in the technical textiles discipline. Given South Africa's energy challenges, a Wi-Fi rechargeable bag was invented through the collaboration between the Tshwane University of Technology-based technology station for electronics (TSE) and the TSCT. Document analysis shows that *'Innovator... displays his patented AOEN bag (Wi-Fi recharging bag) at the National Science Week exhibition'* **Doc**. These findings indicate that a patent was successfully developed into a physical product and thereafter introduced to the market for commercialisation. Given the malaria challenges in Africa, the TSCT participated in the invention of mosquito-repellant socks. A respondent shared that *'We assisted him in developing mosquito-repellent socks. So, he developed a chemical to repel mosquitoes, and we made it into socks'* **Int**. These findings underscore that the TSCT has technical textile capabilities employed in developing mosquito-repellent socks. It is also unclear from the findings if the mosquito-repellent socks completed the commercialisation process. While discoveries exist, the challenge is turning them into products that benefit society.

The findings show that the TSCT, in collaboration with a clothing firm that produces sports clothing, discovered a production method that utilises welding techniques. It was shared by the respondent that *'Collaborating on this project with a local producer of sports clothing has identified weldable technical textiles which can be used to produce garments suitable for cycling'* **Doc**. These findings show that the TSCT and a firm have made a scientific discovery that will improve production techniques and cycling clothing products. These findings show that the TSCT has produced scientific discovery outputs.

Document analysis shows that South Africa's scientific output was low when compared globally. It was indicated in the documents that *'to maintain and increase the relative contribution of South African researchers to global scientific output'* **Doc**. It was also mentioned that only a small proportion of the scientific discoveries generated by South African research institutions successfully reach the commercial market. The respondent articulated this challenge in this way: *'Technologies that exist at universities and science councils... are not getting to the market'* **Int**. These findings underscore an awareness by

the TSCT of these challenges (increasing the rate of scientific discoveries, their commercialisation, and their speed to markets). Furthermore, the findings indicated that TSCT is aware of the lack of a sizing chart for South Africa. A respondent indicated that *'The 3D body scanner project is ongoing... and there is 'no South African size chart'* **Int**. Being in the position of one of the two 3D body scanners in South African universities (Mbatha & Mastamet-Mason 2023), the TSCT is correctly positioned to pursue this opportunity. The TSCT has the potential to lead advancements in garment fit within the clothing and textile sector, thereby enhancing overall competitive advantage.

Graduates with relevant skills output

The findings showed that TSCT produces graduates with relevant skills as an output through work-integrated learning and exposure to technology and industry expertise. A respondent expressed the purpose of technology stations as *'Technology stations are meant to be that platform where students can get their training and work-integrated learning... and get some form of work experience... they [students] can be assisted to get technical skills'* **Int**. The TSCT sourced funding from the DST to house interns to transfer science and technology skills related to the clothing and textiles industry. Document analysis revealed that *'The DST funded ten internships with the TSCT'* **Doc**. A respondent provided the following testimony to support the claim that skills are effectively transferred through internship programmes:

***Int** – A lot of the students might spend a year with us, some of them even eight months, before they finish their internship...companies recruit them to come to work for them because of relevant experience.*

This shows that the TSCT produces graduates with relevant skills as output. This finding shows that employers view interns as highly desirable candidates specifically due to their previous experience at the TSCT. Document analysis highlights the TSCT's thinking behind the skills developed; *'Students must be skilled in the latest technology. Rather than just teach students about what's available now, we are looking ahead and advancing our students'* **Doc**. This is corroborated by a respondent:

***Int** – For example, we are now teaching students how 3D technology works, then in a year or two, students will be going out here [TSCT] also with that type of knowledge, using it in the industry.*

A respondent outlines the TSCT strategy to produce graduates with relevant skills by adding that *'Try to engage with the industry regularly to understand their needs'* **Int.** Given these strategies to ensure that the TSCT produces graduates with relevant skills, challenges do exist. While the TSCT stated that they engage the industry to understand their needs, incorporating these needs into the curriculum is not an easy process. A respondent corroborates this in stating that *'trying to adapt their curricula to make sure that it's updated or is in line with the industry'* **Int.** University curriculum updates often progress slowly, whereas the clothing and textiles industry evolves rapidly, leading to a discrepancy between academic instruction and current industrial practice.

Discussion

As per the South African government's mission, technology stations were meant to solve industry problems and assist with prototyping, piloting, and commercialisation, as well as contribute to socioeconomic development (TIA, 2019). The discussions concerning the findings of this paper will be established upon this mission and the variables identified by Kruss and Visser (2017).

The findings highlighted that the TSCT produces as outputs: academic publications, dissertations, theses, academic collaboration, and scientific discoveries, as well as graduates with relevant skills. However, the quality of outputs varies per variable. The degree of challenges and opportunities also varies, but they underscore the potential for effective and better contributions to the NDP, SDGs, and African Union Agenda 2063. These findings underscore that the TSCT also contributes to the South African clothing and textiles industry and socioeconomic development, yet the extent of these contributions remains unknown. The findings corroborate Ranga (2012), who narrates that innovation could solve structural problems arising from the shift from an industrial society to a knowledge-based society. Furthermore, these findings support the Triple Helix theory, which posits that socioeconomic development can be a direct outcome of collaborations between research and development entities (Etzkowitz & Zhou, 2018).

The findings show that the TSCT collaborates with international, national, and regional actors, as well as various government and research institutions. The findings corroborate with Kruss and Visser (2017),

stating that universities of technology have a scientific reputation in niche areas and tend to engage with large national firms and SMEs. While Sihlobo and Mbatha (2022) and Mbatha and Mastamet-Mason (2021; 2022; 2023) found that collaborations are weak in the university, industry, and government context, these findings show that they are stronger in the context of the TSCT.

The findings indicated that the TSCT had played a role in improving innovation and competitive advantage in the clothing and textiles industry of South Africa. The findings further show that the TSCT is pursuing the development of the South African sizing chart, given its 3D technology capabilities. Despite these findings, the Industrial Policy Action Plan reviewed makes no mention of the role of TSCT interventions within the South African clothing and textiles sector prior to 2017 (Mbatha & Mastamet-Mason, 2023). The absence of the TSCT in government strategies to improve the clothing and textiles industry underscores the policy inconsistencies found by Mbatha and Mastamet-Mason (2023). These findings show that government policy development and strategies could benefit from including the TSCT in their policy development strategies, given the TSCT's capabilities.

Porter (1990) indicated that high-level skills and research organisations within specialised fields are vital for creating innovative products that can secure a competitive advantage. The findings show that the TSCT uses its collaborations to source advanced skills (inviting visiting international scholars and working with other technology stations and advanced manufacturing laboratories) that are not available within the TSCT to explore research projects that are sophisticated for the benefit of the clothing and textiles industry of South Africa. These endeavours underscore that TSCT is increasing its status as a research institution in sophisticated disciplines. Being a research institution in sophisticated disciplines may improve its advanced skills and potential to influence competitive advantage, as positively advocated by Porter. Mbatha and Mastamet-Mason (2018) advise that the clothing and textiles industry of South Africa needs a research institution in sophisticated disciplines. These findings suggest that the development of the TSCT as a research institution in sophisticated disciplines is still in the early stages but progressing well, given the absence of thesis outputs. These findings show that the TSCT may play a stronger role in improving the rate of innovation and competitive advantage in the clothing and textiles industry of South Africa, which has been low (Molekwa et al., 2021).

As a technology station, TSCT has demonstrated that it has a role to play in the sectoral systems of innovation of the clothing and textiles industry of South Africa, which was found to be incoherent by Mbatha and Mastamet-Mason (2023). Comparing the findings from the TSCT to studies observed internationally (Milshina et al., 2019; Rahemtulla et al., 2019; Satharasinghe et al., 2019), the TSCT is not yet on par with other technology stations. This underscore that more work is required from all stakeholders (TSCT, university, industry, government, clusters, clothing and textiles consulting firms, SMMEs, and NGOs) to develop TSCT into a technology station that conducts research in sophisticated disciplines critical for the development of competitive advantage, as argued by Porter (1998).

The TSCT described in this study serves as the foundation for various scientific advancements related to the clothing and textiles industry. These findings corroborate Mbatha and Mastamet-Mason (2021), who also observed scientific discoveries in the clothing and textile industry of South Africa. The scientific discovery from TSCT may contribute to SDG 8 and AU Agenda 1, demonstrating that the TSCT is correctly positioned to contribute to the socioeconomic development of South Africa and the continent. The findings suggest that the drive for researchers to publish or complete their dissertations is not being effectively applied, failing to increase the rate at which knowledge is disseminated outlined that researchers' rush to publish and complete dissertations is not applied, highlighting that the diffusion of knowledge is not happening at a higher rate. The diffusion of knowledge problem characterising the TSCT and universities with clothing-related qualifications is corroborated by Mbatha and Mastamet-Mason (2023), as they indicated that universities are slow in diffusing new knowledge produced from dissertations and theses. These challenges underscore sectoral systems of innovation inconsistencies highlighted by Mbatha and Mastamet-Mason (2023). These findings show that the TSCT may be underperforming on its government mandate to diffuse knowledge to solve industry problems. While this is the case, it should be acknowledged that the TSCT has taken steps to address this challenge and deployed three staff members with advanced skills (doctoral qualifications) into the industry to conduct research for the sole purpose of diffusing it for industry use (TIA, 2019).

Conclusion

This study explored how traditional academic outputs are produced and what challenges and opportunities exist in the technology station. The paper found a fair amount of traditional academic output from the TSCT. The challenges identified emphasised that the TSCT can produce an improved quality of traditional academic outputs that deliver on its government mission and socioeconomic development contribution. The paper highlighted that there are opportunities for more diffusion of knowledge, resulting in the TSCT being an institution conducting research in sophisticated disciplines, and contributing to the development of competitive advantage in the clothing and textiles industry of South Africa. This paper provides empirical evidence that actors in traditional academic outputs can address whether the clothing and textiles industry of South Africa is to achieve its objectives set out in the Clothing and Textiles Master Plan 2030 (Barnes, 2018).

For the technology station, a greater emphasis must be placed on achieving its government mission of solving industry problems, assisting with prototyping, piloting, commercialising, and contributing to socioeconomic development (DTI, 2016). This means that more effort should be placed on applying the results from dissertations and prioritising the diffusion of new knowledge, and not on publications. Increase the role played by the TSCT in the development and execution of the Industrial Policy Action Plan, given traditional academic outputs, advanced skills, and technology.

For the policymakers, this paper highlighted policy gaps that result in less new knowledge (among other consequences) being disseminated by the TSCT. This paper points to a greater need to improve policy alignment to yield better returns from the R&D expenditure by the government. The government should invest more effort to involve the TSCT in the development, execution, and monitoring of the Industrial Policy Action Plan of the clothing and textiles industry of South Africa.

This paper shows that the TSCT can positively influence competitive advantage for the industry. The industry should find means to develop a level of trust with the TSCT to allow the TSCT to work on areas regarded as trade secrets by the industry in order for the TSCT to unlock a competitive advantage for the clothing and textiles industry. Research about trade secrets within the clothing and textiles sector ought to be

withheld from publication until industry consent is secured, typically following a period during which the sector has capitalised on the research. These findings provide a basis for subsequent research aimed at gaining a more profound insight into how innovations and knowledge produced within research institutions are spread. There is a need to conduct research on the commercialisation of the scientific discoveries found in this paper. There is a pressing requirement to determine whether a viable value chain for the dissemination of new knowledge is present in South Africa and, if so, what obstacles hinder this diffusion process. There is a need to research how the TSCT addresses the Industrial Policy Action Plan, the SDGs, and the African Union Agenda 2063 objectives. Lastly, further studies are required to explore the socioeconomic outputs arising from the TSCT. These studies are crucial for the clothing and textiles master plan vision 2030, the clothing and textiles industrial policy (IPAP 2018), the SDGs 2030 (Mbatha & Mastamet-Mason, 2021), and the sectoral systems of innovation (Mbatha & Mastamet-Mason, 2023).

Declarations

Acknowledgements

This paper arises from a master's degree study. The authors of this article are grateful to all respondents who offered their valuable time to provide data. We are grateful for the editorial work by Tanya Pretorius.

Funding

The study is partially supported by the National Research Foundation of South Africa [Grant Number: 107395] and Botshegetse. Opinions and conclusions are those of the authors and should not necessarily be attributed to the funders.

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