








Digital Transformation of the Textile and Fashion Design Industry in the Global South: A Scoping Review

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Abstract. This paper focuses on the digital transformation of the textile and fashion design industry of developing countries in the Global South. Its goal is to describe the state of the art and determine the topical trends, challenges, and opportunities associated with the digital transformation of the textile industries in the Global South. We conducted a scoping review of 16 studies and followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis and Scoping Reviews Protocols (PRISMA-ScR) guidelines. The search string was composed, and searches were conducted on some selected digital libraries and databases. We summarised each study and analysed it based on emerging commonalities. We performed quantitative and qualitative analyses of the included studies. The results reveal that transition to sustainable and smart production is an ongoing slow process in the textile and fashion design industry in the Global South. Textile production is embracing Industry 4.0 in practice based on intelligence systems. Sustainability dimensions can be incorporated into the value chains with digital technologies. The study implies that emerging firms can leverage the recent development in textile production to achieve more sustainable production practices. The study can also be a reference for inspiring the digital transformation of the textiles and fashion industry in developing countries, Nigeria in particular.

Keywords: Digital Transformation · Textile and Fashion Industry · Global South · Environmental Sustainability · Scoping Review

1 Introduction

Textiles are indispensable for human existence (clothing, household, furnishing). The textile industry is saddled with manufacturing these articles for human convenience. Textile and fashion design is also a significant contributor to the economic growth of

many countries [1–3]. However, with technological advancement and an increase in demand for textile products and services, coupled with the drive for compliance with industrial revolutions happening in the industry, the textile and fashion design industry, over the years, has faced different challenges in coping with these trends.

Digital transformation is one of the significant trends in this industry. The definition of digital transformation varies according to what is peculiar to different authors; therefore, there may be no single definition for digital transformation. A recent systematic review by Morakanyane et al. [9] collected and synthesised definitions offered by eleven authors. From the eleven definitions, key issues central to digital transformation are digital technologies, processes, and change. Therefore, we define digital transformation as the necessitated changes in processes, whether business organisations or societies, usually driven by technological advancements, primarily digital technologies.

Digital transformation is an ongoing trend in industrial sectors such as manufacturing (food, wood, metal), construction, marketing, and creative industries such as textile and fashion design, especially as compelled by industrial revolution frameworks. Although some existing reviews focus on the textile and fashion industry, none of them is, in particular, focused on the state of affairs in the Global South. In their review, Islam, Perry and Gill [7] mapped environmentally sustainable practices in the textile, apparel and fashion industries and found there are diversities and complexities regarding environmentally sustainable practices in the industry. Moreover, the study reveals a paucity of studies from developing countries, and it is just time for us to examine the trends, challenges and opportunities for the Global South. Similarly, Conlon [3] conducted a systematic review to understand Product Lifecycle Management (PLM) - ‘an enterprise-wide strategy gaining prominence across manufacturing’ practice in the textile and fashion industry. Conlon [3] found a limited holistic and theoretical view of PLM and a shortage in relevant industry skills as primary hindrances to PLM adoption and optimisation in the sector. It is, therefore, necessary to investigate digital transformation activities of the textile and fashion industry, especially the Global South, since Conlon [3] focused on the Global North. In another related review, Rahman [11] examined the application of digital technologies in the textile and fashion industry and found that implementing digital technologies such as 3D printing can help reduce production costs and increase profitability. Although the results are promising, the focus is global, and it is not so clear what the situation is in the Global South.

A scoping review makes it possible to quickly map significant concepts underlying a research area and types and sources of available evidence to provide a foundation for conducting a comprehensive review later (Mays et al. [8] cited in Arksey & O’Malley, [2]). Our goal is to examine scholarly literature, describe state of the art, and determine the trends, challenges and opportunities associated with the digital transformation of the textile and fashion industry in the Global South. Table 1 is the overview of our research objectives and questions.

The rest of the paper is organised as follows: Sect. 2 describes the study methodology, Sect. 3 describes the results, Sect. 4 is the discussion and Sect. 5 describes the conclusions.

Table 1. Research objectives and questions

| S/N | Objectives | Specific Research Questions (RQs) |
|-----|--|---|
| 1 | Determine the digital transformation trends of the textile and fashion design industry in the Global South in the last three decades | What topics characterise the textile and fashion design industry research in the Global South in the last three decades, and in which countries are these conducted? |
| 2 | Investigate challenges the industries faced within the study period | What documented challenges in the extant literature confront the textile and fashion design industry in the last three decades, and how are these classified? |
| 3 | Identify the methods used by researchers to conduct studies | What research methods have been used by the current scholarly works? |
| 4 | Identify the opportunities for digital transformation in the textile and fashion industry | What opportunities are there for the textile and fashion industry in the Global South to digitally transform based on documented evidence from the existing literature? |

2 Methods

We conducted a scoping review and followed the PRISMA-ScR guidelines. Our review goal aligns with Arksey and O'Malley's [2] four fundamental reasons for conducting a scoping review; investigate the range, extent, and nature of research activity, determine the need to undertake a comprehensive systematic review, summarise and disseminate the results; and determine the gaps in the extant literature.

2.1 Protocols and Registration

We drafted our protocol employing the PRISMA-ScR. The research team revised the protocol. The final protocol was developed on 18 July 2022.

We decided that our focus shall be on the digital transformation of the textile industries of developing countries in the Global South. Our goal is to describe the state of the art of these industries and determine the topical trends, challenges, and opportunities associated with the digital transformation of the textile industries. As a result, we decided that all the included papers must align with this goal.

2.2 Inclusion and Exclusion Criteria

Based on our broad study goal, we selected papers where the research was in the context of developing countries in the Global South. We wanted to determine the roles of digital technologies, people, and processes in the digital transformation of the textile industries in this region. Further, we wanted to determine the methods employed by researchers to carry out the studies.

The rest of the eligibility criteria is as follows:

Inclusion Criteria

1. Written in English
2. Conference or journal articles
3. Published between 1992–2022
4. At least four pages
5. Peer-reviewed
6. Accessible online
7. Developing country in the Global South

Exclusion

1. Book Chapters, Magazines, Opinion papers, Theses, Blog Posts, Workshops and Panel papers

2.3 Information Sources

Table 2 details the bibliographic databases and digital libraries in which we conducted our search. The search was conducted on 20 July 2022. One of the authors, who is well-experienced in conducting systematic reviews, drafted the search strategies. We refined the search strategies further through team discussion. We exported the final search results to Mendeley, where one of the authors processed the bibliographic details of the studies.

Table 2. Details of the search results.

| Database or source | Screening by titles and abstracts | Duplicates | Studies sought for retrieval | Included based on inclusion criteria | Final inclusion |
|------------------------|-----------------------------------|------------|------------------------------|--------------------------------------|-----------------|
| ACM DL | 124 | 0 | 12 | 2 | 2 |
| Elsevier | 7 | 0 | 5 | 4 | 4 |
| IEEE Xplore | 13 | 0 | 10 | 5 | 5 |
| Taylor & Francis | 302 | 0 | 7 | 1 | 1 |
| Wiley Online | 212 | 0 | 8 | 1 | 1 |
| African Journal Online | 11 | 0 | 2 | 1 | 1 |
| Springer | 199 | 0 | 10 | 2 | 2 |
| Total | 868 | 0 | 54 | 16 | 16 |

We used a classification¹ to verify the regional setting of countries, that is, those that belong to the Global North from those in the Global South. As a result, we ensure to include studies from only developing countries in the Global South.

2.4 Search Strategy

All the researchers decided on the composition of the search strings to increase consistency. We composed the search string: (*'textile' OR 'fashion' design*) AND (*'digital transformation' OR digit* transform* OR digital technolog* OR industry 4.0 OR industry 5.0 OR Smart industry OR Zero Waste*) AND (*Global South OR Developing countr**) AND [*Publication Date*]: 01/01/1992 TO 31/07/2022.

2.5 Selection of Sources of Evidence

Each researcher was assigned digital libraries and databases to search, and the researchers screened the results together. Since each digital library and database have peculiarities, we amended the screening where appropriate. Five researchers in a workshop set up worked together to agree on at what point the screening iteration should stop, and we documented the search process results. Figure 1 is the search process.

2.6 Data Charting Process

A data-charting workshop was held in which all the five researchers decided what data to extract from included studies. We created a table in the Google doc where we collated the variables to extract from studies.

We iterate the process a couple of times until all the researchers feel satisfied with the data charting.

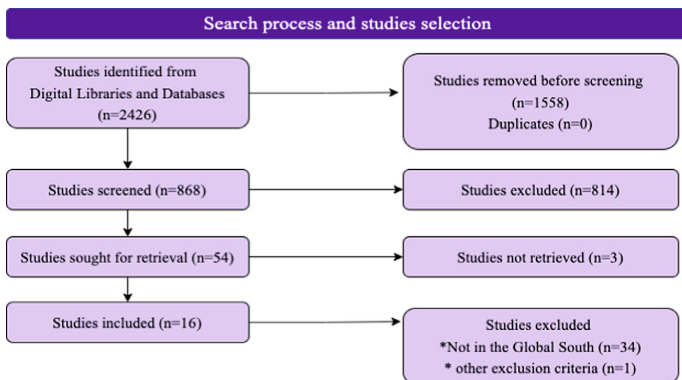


Fig. 1. The search processes.

¹ The classification was found at https://meta.wikimedia.org/wiki/List_of_countries_by_regional_classification.

2.7 Data Items

We created a Google spreadsheet and extracted data on characteristics of studies (e.g., article/paper title, author keywords, year publication, source of publication, study type, and country of study). Also, contextual issues reported in the study (e.g., issues relating to digital transformation, technologies and roles, processes, challenges, and opportunities), study methods, sample size, and significant findings.

2.8 Synthesis of Results

We collated the studies into behavioural and non-behavioural-based studies. We summarised each study design and analysed it based on emerging commonalities, for example, evidence of intervention, impact, challenges, and trends. As a result, we performed quantitative and qualitative analyses of the included studies. We compiled tables, figures and charts for the visual representation of quantitative data and added some narratives regarding qualitative data. We mapped emerging evidence to create a trajectory for future research.

2.9 Demographic Data

The final inclusion of studies comprised eight conference papers and eight journal articles. The publications count by year is as shown in Fig. 2. The figure shows one published article in 2006, 2014, 2015, 2017 and 2020, respectively. There were two publications in 2011, 2018 and 2020, respectively, and five in 2021. The studies were conducted from 2006 to 2022, with five conducted in China, 2 in Taiwan, and one in Pakistan, Egypt, Malaysia, Kazakhstan, South Africa, Saudi Arabia, Brazil, Columbia and Thailand. Figure 3 shows the results of nestling the keywords of the included papers, and it can be seen that themes such as Industry 4.0, dyeing, decision, textile, and design dominate the author’s keywords. We also concatenated and mined the abstract texts of the 16 papers in a Voyant tool² to determine what trends can be inferred from the studies.

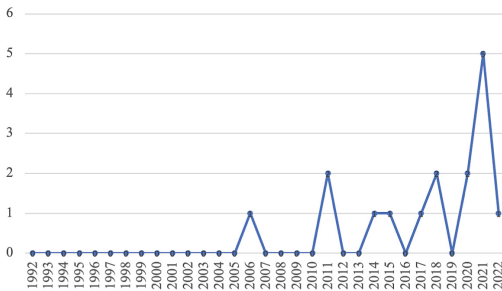


Fig. 2. Publications count by year

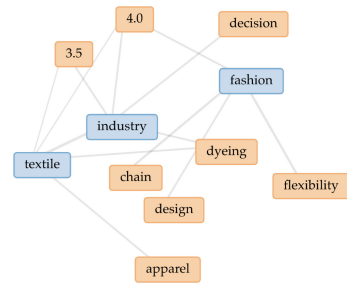


Fig. 3. Keywords mapping

The results in Fig. 4 show the sixth-most frequently used words in the corpus are fashion (n = 32), textile (n = 24), industry (n = 22), study (n = 19), design (n = 14), and technology (n = 14).

² <https://voyant-tools.org/>.

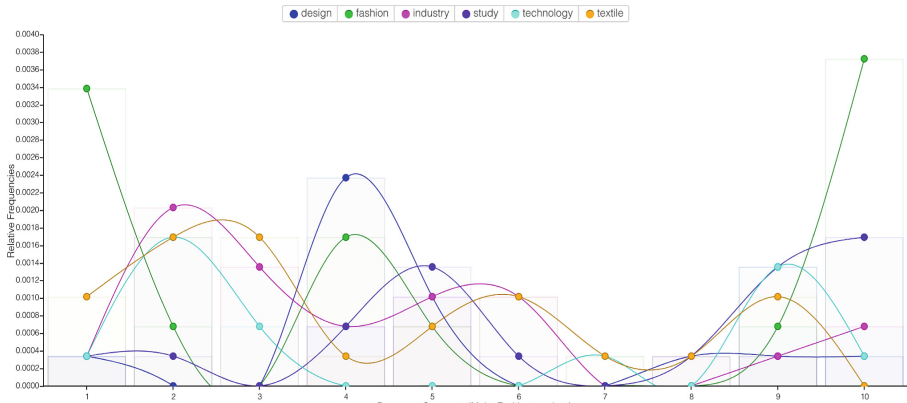


Fig. 4. Abstracts trends corpus

3 Results

RQ 1. *What topics characterise the textile and fashion design industry research in the Global South in the last three decades, and in which countries are these conducted?*

First, we created a timeline of events and topics dominating the research for the period of selected studies. As seen in Fig. 5, the results indicate that many of the studies investigated Industry 4.0 compliance. Seven studies examined readiness, environmental sustainability, smart production, and IoT platform interoperability. One study, in particular, proposed an in-between framework called Industry 3.5, which the authors believe is more compatible with the Global South. As can be seen in Fig. 5, Industry 4.0 framework compliance has been consistently investigated from 2011 to date. Figure 6 is the result of aggregating the various firms and technologies used in the textile and fashion industry. The result can be classified into raw materials (for example, chemical fibre), processing (for example, embroidery, cutting, weaving, dyeing and finishing, and printing, and the final product (for example, clothing, children’s garments).

Next, we distributed the sixteen included studies into countries where the research focused on. Table 3 shows that most of the studies came from China ($n = 5$) followed by Taiwan ($n = 2$). Other countries with less textile studies include Brazil, Pakistan and South Africa. Overall, the results in Table 2 reveal a paucity in research and suggest China is leading in research on textile and fashion industry.

Data obtained from the study signified the systematic shift in production based on the industrial revolution. Textile production followed this trend by moving from technology in the first industrial revolution to the fourth industrial revolution.

RQ 2. *What documented challenges in the extant literature confront the textile and fashion design industry in the last three decades, and how are these classified?*

Figure 7 shows the challenges delineated from the sixteen studies reviewed for the study. Technologies have brought tremendous changes in textiles and fashion in the last three decades—nevertheless, the industry-specific challenges via technology

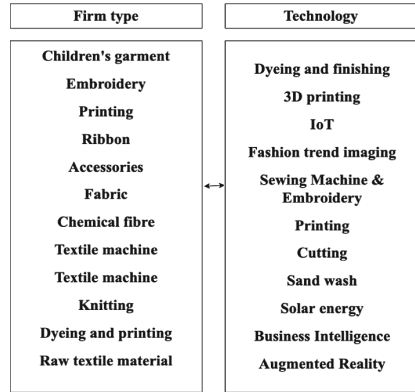
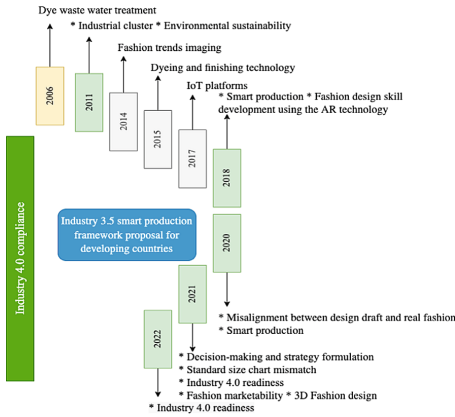


Fig. 5. Timeline of topics dominating the study period

Fig. 6. Firm types and technologies in use

Table 3. Distribution of studies by countries

| Countries | Frq | References |
|--------------|-----|------------------------------------|
| China | 5 | STD 3, STD 4, STD 7, STD 8, STD 11 |
| Taiwan | 2 | STD 10, STD 13 |
| Pakistan | 1 | STD 1 |
| Egypt | 1 | STD 5 |
| Malaysia | 1 | STD 6 |
| Kazakhstan | 1 | STD 9 |
| South Africa | 1 | STD 12 |
| Saudi Arabia | 1 | STD 14 |
| Brazil | 1 | STD 15 |
| Colombia | 1 | STD 16 |
| Thailand | 1 | STD 2 |

deployment are apparent. We classified the challenges into technology, raw materials, process, and industry 4.0 transition.

Three studies from the sixteen (16) studies reviewed based on the specified inclusion criteria reveal that technological challenges hinge on 3D dyeing and finishing and 3D printing. Regarding 3D printing design, STD 7 reported a challenge of non-real user interactivity with 3D design textiles. Dyeing and finishing had increasing demands for a quality product (STD 1, STD 3), production of comfortable fabrics (STD 4), fabric colours (STD 2, STD 3), special requirements for new fibres (STD 3), development of unique designs (STD 3), ecology and economic situation awareness (STD 3), environmental pollution control (STD 3, STD 5), high efficiency and low energy demands (STD

| Technology | | Process | | Raw Materials | | Industry 4.0 Transition | |
|--|---|--|---|--|--|---|---|
| Dyeing and finishing | 3D printing | Batch-dyeing-scheduling | Design draft | Fashion trends | Fashion size charts | Top management lack of awareness | Organisational awareness credibility |
| <ul style="list-style-type: none"> * Increasing demands for quality product * Production of comfortable fabrics * Fabric colours * Special requirements for new fibres * Developing unique designs * Ecology and economic situation awareness * Pollution control * High efficiency and low energy demands * Optimal configuration process * Solar irradiation for dye water treatment | <ul style="list-style-type: none"> * non-real-time user interactivity with 3D design textile | <ul style="list-style-type: none"> * Sequence-dependent setup * Parallel machines * Arbitrary production size * Incompatible production family * Non-relational data storage * Increasing job order complexity and variation | <ul style="list-style-type: none"> * Performance limitation to existing digital design tools | <ul style="list-style-type: none"> * demand and supply mismatch * Over-reliance on textile producers * fashion trend books to inspire fabric designers * Hindrances to decision making process | <ul style="list-style-type: none"> * Full-fledged, pear-shaped SA women | <ul style="list-style-type: none"> * Use of traditional and physical sales channels * Non-detailed product customisation * Limited ICT budget * Lack of digital features in products/services * Lack of strategic transition implementation plans * Lack of machine-machine communication * Firm-suppliers relationship modification * Lack of supplier buy-in * Poor waste management system * High costs of cleaning system | <ul style="list-style-type: none"> * Variations in customer awareness in the target market |

Fig. 7. Mapping of challenges found in studies

3, STD 5, STD 11), optimal configuration process (STD 3), and solar irradiation for dye water management (STD 11).

Raw material constituted two arrays of difficulty: fashion trends and fashion size charts. Specifically, fashion trends face the challenge of demand and supply imbalance (STD 2), over-reliance on textile producers (STD 2), fashion trend books to inspire fabric designers (STD 2), and hindrances to the decision-making process (STD 2).

Process challenges border on batch-dyeing and design drafts. The design draft caused performance limitations to the existing digital design tools (STD 8). Batch-dyeing linked sequence-dependent setup (STD 13), parallel machines (STD 13), arbitrary production size (STD 13), incompatible production (STD 13), family, non-relational data storage (STD 13), and increasing job order complexity and variation (STD 10) are other process-related challenges. The design draft led to performance limitations to existing digital design tools (STD 8).

Industry 4.0 transition challenges are top management’s lack of awareness led to organisational awareness creation (STD 3, STD 5, STD 9), credibility, and variations in customer awareness in the target market (STD 5). The other pressing challenges for the industry 4.0 transition are the use of traditional and physical sales channels (STD 9), non-detailed product customisation (STD 9), limited ICT budget (STD 9), lack of digital features in products/services (STD 9), lack of strategic transition implementation plans (STD 9), lack of machine-machine communication (STD 9, STD 13), firm-suppliers

relationship modification (STD 2, STD 4, STD 5), lack of supplier buy-in (STD 5), and poor waste management system (STD3, STD 5, STD, 6, STD 11).

RQ 3. *What research methods have been used by the current scholarly works?*

The current scholarly works use various research methods, as presented in Table 4. We classify the studies into behavioural and non-behavioural-based. Most of the studies are non-behavioural-based studies. These studies do not focus on people's behaviour in a given social context or under some controlled observation. The results show that modelling ($n = 8$) is the primary method used. Modelling is a method used in physical sciences. Mathematical models are a typical example. Other methods are interview method ($n = 4$). Experiment ($n = 3$), survey ($n = 3$), case study ($n = 3$), and expert review ($n = 1$) are the other used methods. As can be seen in Table 3, six of the studies (STD 1, STD 4, STD 5, STD 9, STD 14, and STD 15) used mixed methods, that is, more than one method, and that explains why the total frequency of the methods used is 22.

Sample sizes vary by study, and the results reveal that the unit of analysis determines the sample size, that is, individuals or companies.

RQ 4. *What opportunities are there for the textile and fashion industry in the Global South to digitally transform based on documented evidence from the existing literature?*

The results in Table 4 harmonise the textile and fashion industry indicators to transition to green operations. The green value chain indicators were retrieved from the 16 included studies. From Table 5, we can see that leadership/company innovativeness ($n = 7$) and water usage efficiency ($n = 7$) are the topmost indicators of creating a green value chain for the industry. It is well-known that the value chain describes activities that are essential to enhance a competitive edge. Other indicators according to their frequencies are environmentally-friendly equipment/technologies ($n = 6$), sustainable product design ($n = 5$), government policy ($n = 5$), waste removal ($n = 4$), energy efficiency ($n = 4$), pollution reduction ($n = 2$), and renewable material sourcing ($n = 1$). The findings revealed that achieving a "green" value chain will involve integrating environmental management strategies into all value chain activities, as presented in Table 5.

Other opportunities revealed through the review of the extant literature for promoting digital transformation of the textile and fashion industry in the Global South indicate that digital transformation can integrate information from separate systems. In particular, there is the need to structure dyeing and finishing (STD 1, STD 3), use digital tools to enhance design user interactivity, and look into performance and malleability (STD 7). Also, review the decision support system for dyeing machine scheduling (STD 10), develop country-specific fashion size charts (STD 12), and put in place efficient dye wastewater treatment (STD 11).

Table 4. Methods applied in studies and issues addressed

| Studies Code | Methods | | | | | | Sample Size |
|--------------|------------|-----------|-----------|--------|------------|---------------|--|
| | Experiment | Modelling | Interview | Survey | Case Study | Expert Review | |
| STD 1 | | | x | | x | | 3 (company case studies) - 9 semi-structured interviews |
| STD 2 | x | | | | | | CBIR with five well known descriptors |
| STD 3 | | x | | | | | NA |
| STD 4 | | | x | | x | | 2 innovation platforms case studies (16 semi-structured interviews) |
| STD 5 | | | x | | x | | Unspecified number of semi-structured interviews |
| STD 6 | | | | x | | | 42 experts (31 professionals, 5 BI vendors, and 6 academic researchers.) |
| STD 7 | | x | | | | | NA |
| STD 8 | | x | | | | | NA |
| STD 9 | | x | x | | | | 27 employees |
| STD 10 | | x | | | | | none |
| STD 11 | | x | | | | | none |
| STD 12 | x | | | | | | 150 full-figured women with pear-shape body |
| STD 13 | | x | | | | | none |
| STD 14 | x | | | x | | | 54 students |

(continued)

Table 4. (continued)

| Studies Code | Methods | | | | | | Sample Size |
|--------------|----------|----------|----------|----------|----------|----------|--|
| STD 15 | | x | | | | x | 10 (comprising 4 experts and 6 managers/practitioners) |
| STD 16 | | | | x | | | 13 companies |
| Total | 3 | 8 | 4 | 3 | 3 | 1 | NA |

Table 5. Green value chain indicators for the textile and fashion industry

| Studies | Green value chain indicators | | | | | | | | |
|--------------|------------------------------------|----------------------------|-------------------|------------------------------|---------------|-------------------|---------------------|--|------------------------|
| | Leadership /company innovativeness | Sustainable product design | Government policy | Renewable materials sourcing | Waste removal | Energy efficiency | Pollution reduction | Environmentally-friendly equipment /technologies | Water usage efficiency |
| STD 1 | x | | | | | | | | |
| STD 2 | | | | | | | | | |
| STD 3 | | | | | | | | x | x |
| STD 4 | | | x | | | | | | |
| STD 5 | x | x | x | x | x | x | x | x | x |
| STD 6 | x | | x | | x | x | x | | x |
| STD 7 | | x | | | | | | | |
| STD 8 | | x | | | | | | | |
| STD 9 | x | x | x | | | | | | |
| STD 10 | x | | | | | x | | x | x |
| STD 11 | | | | | x | x | | x | x |
| STD 12 | | | | | | | | | |
| STD 13 | | | | | | | | | x |
| STD 14 | | | | | | | | | |
| STD 15 | x | x | | | x | | | x | |
| STD 16 | x | | x | | | | | x | x |
| Total | 7 | 5 | 5 | 1 | 4 | 4 | 2 | 6 | 7 |

4 Discussion

4.1 Topical Issues and Trends in the Textile and Fashion Industry in the Global South

The textile and fashion industry are a significant contributor to the national economy of many developing countries (STD 1, STD 6, STD 9). Our findings show that China is leading the research on the textile and fashion industry and the finding is consistent with a systematic review by [7] that investigated environmentally sustainable practices in textiles, apparel and fashion industries and found most of the researches are from China. However, due to the need for digital transformation, some textile and fashion industries in developing countries have faced some decline and need upgrading (STD 3). On the one hand, the absence of digital transformation in the textile and fashion industry in the Global South is due to the lack of government policies to drive such transformation (STD 4). On the other hand, it is due to a lack of readiness to embrace green and smart production (STD 6, STD 9, STD 10).

In some developing countries, the need to adopt sustainable and smart production is due to the need for a ‘cleaner and unpolluted global environment’ (STD 5), ‘global competition for mass customisation to address dynamic customer demands’ (STD 10), and energy efficiency (STD 11). Nevertheless, some developing countries have shifted their focus to sustainable development in their industrial sectors, especially textile and fashion design (STD 5). In particular, STD 10 found the global framework, Industry 4.0, not so implementable for the Global South and proposed a mid-range framework called Industry 3.5. It is noteworthy that Industry 5.0 is now in force regarding implementation in the Global North. The Global South textile and fashion industry results reveal a dichotomy between the two regions and suggest developing frameworks and guidelines for standard practices in contexts. STD 13 developed a ‘Multi-subpopulation Genetic Algorithm with Heuristics Embedded (MSGGA-H) to reduce the makespan to enhance textile batch dyeing scheduling bottlenecks. The study responded to the need to transition the textile and fashion industry to operating under the industry 4.0 framework. In the same vein, STD 6 extended the Technology, Organisation and Environment (TOE) framework based on business intelligence dimensions to facilitate the adoption of advanced technologies in the textile and fashion industry.

Overall, our results reveal that although the transition to sustainable and smart production is an ongoing process in the textile and fashion industry in the Global South, there is a paucity of studies investigating this issue. Our finding is consistent with Islam, Perry, and Gill’s [7] review, which revealed that research is scarce from developing countries even though the Global South is the leader in textile, apparel, and fashion production. Green value chain adoption is an opportunity for the textile and fashion industry to transition smoothly to Industry 4.0. Although one can argue that the industry 5.0 framework has superseded the industry 4.0 framework, it is a well-known fact that there is a significant digital divide between the highly industrialised Global North and the developing Global South. Our results suggest that research focusing on the digital transformation of the textile and fashion industry has slowly started since 2006 and not growing to date. Industrial revolutions in the manufacturing and creative industries seem to be the main

focus for researchers, although other issues such as decision-making, leadership, and strategic management were the researchers' focus.

4.2 Challenges Confronting the Textile and Fashion Industry in the Global South

There are particular challenges facing the industry, but our findings reveal that some of the reviewed studies focused on proffering solutions to the afore-stated problems in Sect. 4.1. For example, STD 11 proposed 40 CdF2 60 BaF2 1.0 Er2O3 - an upconversion luminescence agent to enable solar irradiation or interior lighting efficiency. An upconversion luminescence agent is a technological approach for treating dye wastewaters utilising solar energy, particularly in developing countries' textile industries. Similarly, STD 15 examined the comparative competitive preferences of large retailers' slow and fast fashion retail operations in Brazil and found that price and quality are the most relevant priorities in slow fashion. In contrast, customer relationships and flexibility are significant priorities in fast fashion. The study, therefore, proposed procedures for simultaneously handling the two strategies. STD 15 proposed that Slow fashion companies should reduce costs and improve quality by implementing online process controls. Fast fashion companies should lower lot sizes, increase the variety of blends and assortments, and bolster customer ties. It is noteworthy that fast fashion consumes a significant amount of water and energy because its processes involve extracting raw materials, manufacturing fibres, dyeing, weaving and washing, fibre burning and recycling and waste extraction from clothes [6].

Other peculiar challenges or problems were also addressed. STD 2 used the Content-Based Image Retrieval (CBIR) method to inspire the creation of fashion trends. This challenge is not unlikely, considering varying levels of modernisation across the globe. Other factors that could solve these problems are cultural diversity and personal characteristics, which play pivotal roles in fashion choices and decisions. STD 7 demonstrated 'FlexTruss, a design and construction pipeline based on the assembly of modularised truss-like objects fabricated with conventional 3D printers and assembled by threading' to direct the workflow 'guides the assembly of printed truss modules by threading.' STD 8 examined the 'unaligned translation problem between design drafts and real fashion items' and proposed a 'design draft to real fashion item translation network (D2RNet)', capable of generating 'realistic garments with both texture and shape consistency to their design drafts.' STD 12 developed a statistical model of essential body dimensions (bust, waist, and hip) to define a size chart for producing ready-to-wear apparel for curvy, pear-shaped South African women because of the cruciality of 'anthropometric body measurement' for the textile and fashion industry. Fashion size charts culminating in full-fledged, pear-shaped South African women's study were an anathema to the fashion world as different races have peculiar figure prominence; hence, countries develop size charts specific to the average figures. Just as it is popularly projected that "there is no perfect figure". STD 14 explored the use of augmented reality technology for training university students to acquire fashion design skills. STD 16 examined the prospects of 'Internet of things (IoT) platforms for the industry 4.0 framework implementation.

4.3 Research Methods Used in the Current Scholarly Works

The research methods used in the current scholarly works on the digital transformation of the textile and fashion design industry are either single methods or mixed methods. The methods range from experimentation, modelling, interview, and survey to case studies. Our findings show that Modelling is the mostly used method, followed by the interview method. About half of our studies are non-behavioural inquiry-based, thus, explaining the use of modelling technique. In a related study, Rahman [11] also applied modelling in his study which sought to provide models of different applications of digital printing, 3D printing, artificial intelligence, and radio frequency identification (RFID) in textile manufacturing. Experiments, surveys, case studies, and expert reviews are the other used methods. In other recent review studies such as [7] and [3], the case study was the most used method.

Our findings also show that mixed methods can also be used as one of the approaches for the digital transformation of the textile and fashion design industry. STD 1, STD 4, STD 5, and STD 9 used a combination of methods. This is consistent with Gazzola et al. [5] that also used mixed methods. Overall, we can infer that the nature of the problem of investigation determines the type of method to use. Our study goal was broad whereas other studies streamlined their focus. Conlon's [3] focus was PLM practice in the textile, apparel, and fashion industries. Islam, Perry, and Gill [7] focused on environmentally sustainable practices in the industry.

4.4 Digital Transformation Opportunities for the Textile and Fashion Industry in the Global South

Green value chain adoption is a huge opportunity for the textile and fashion industry to digitally transform their operations, as revealed in our findings. One of the top-most activities for companies to benefit from these opportunities is innovativeness. Environmentally-sustainable equipment/technologies is another indicator for boosting the green value chain for the industry. One of the existing recent review studies (Rahman, 2020) reported increasing demand for digital technologies such as 3D printing in the textile and fashion industry to foster supply chains and promote customer satisfaction. However, the same study revealed there is scarce research on in-depth assessment of applying digital technologies in the industry, especially textile manufacturing and fashion retailing. It is a well-known fact that the textile and fashion industry is a significant contributor to pollution. Nevertheless, production of sustainable fibres such as bio-technology fabrics is a great opportunity for sustainable production [12]. Adaptation of the industrial revolution frameworks such as the industry 3.5 framework proposed by (STD 10) is a huge opportunity for the industry regarding their digital transformation processes. It has also been proposed that the industry can harness the power of digital technologies to build an ecosystem to facilitate cross-pollination and symbiotic relationships among the members of the ecosystem [6, 12]. Such an ecosystem can help to coordinate logistics, processes, productions, supply chain, and value chain for the maximum and sustainable outputs and mutual benefits.

4.5 Limitations, Implications, and Future Research

This study is a scoping review. We might have missed other exciting studies due to streamlining the research to the databases searched, studies written in English, and only accessible studies online, among other inclusion criteria, set and research questions set with broad parameters.

From the studies conducted so far, it is evident from the demographic data presented in Sect. 2.9 that only Egypt and South Africa are the African countries reported in the literature on the digital transformation of the textile and fashion industry, which is consistent with the review by Islam, Perry and Gill (2020) that included only three studies from Africa in their review. The implication of the paucity of studies conducted on the subject area reported in Africa is that researchers need to conduct more research on the pressing issues in the textile and fashion industry, such as environmentally sustainable practices, roles of digital technologies in the digital transformation of the industry, and product lifecycle management adoption among other topics. In-depth studies on what may have led to the paucity of literature on the subject area in African countries, especially Nigeria, are also needed. Second, practitioners in the textile industry in Nigeria and other countries in the Global South should be sensitised and motivated toward the adoption of digital transformation of the textile industry. Governments at all levels (Federal, State, and Local) should endeavour to formulate, evaluate and monitor enabling policies to encourage the adoption of digital transformation of the textile industry.

For future studies, a more in-depth systematic review can be carried out, especially examining the state of the digital transformation of textile and fashion industries in the Global North and the Global South and the dichotomy between these regions - the challenges, lessons learnt, and opportunities.

5 Conclusions

In this paper, we have considered the review papers on digital transformation, which has impacted the industrial sector, especially the creative industries in textile and fashion design. Our study highlighted a total lack of focus on the Global South in the existing literature. Therefore, we carried out a scoping literature review to map the essential concepts to provide a basis for a comprehensive review in the near future.

Our discoveries are: industry 4.0 dominated the studies reviewed, technology, raw materials, process, and industry 4.0 transition are the documented significant challenges confronting the textile and fashion design industry, and half of the studies are non-behavioural and used the modelling research method. Leadership/company innovativeness and water usage efficiency provide the most significant opportunities for the digital transformation of the textile and fashion industry in the Global South.

There is a paucity of studies on the digital transformation of the textile and fashion industry in developing countries. Therefore, we have examined digital transmission trends, challenges, and opportunities in the Global South. We have shown ample opportunities for the digital transformation of the textile and fashion industry in the Global South. One interesting future research is conducting a systematic review of the Global North and South on the subject matter.

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Appendix 1

See Tables 6.

Table 6. Overview of the studies

| Studies Code | Issues addressed | Major outcomes/key findings |
|--------------|--|---|
| STD 1 | Decision-making processes and strategy formulation | The function of leadership and strategy diminished. Five internal factors contributed to the failure: 1) “Seth” management styles and policies; 2) Firm’s culture, politics, and internal disputes; 3) Hostile human resource policies and unfriendly working environment; 4) Poor financial portfolios management; and 5) Operational matters connected to technology, operations, and marketing |
| STD 2 | Creating fashion trends | Tamura texture’s precision and recall outperform the other descriptors. Different fashion style affects the descriptor’s precision and recall efficiency |
| STD 3 | Role of dyeing and finishing technology | The optimal dyeing and finishing process design is fundamental for textile plants. The various quality provisions of the plant can set the input and output of the dyeing and finishing technology |

(continued)

Table 6. (continued)

| Studies Code | Issues addressed | Major outcomes/key findings |
|--------------|--|--|
| STD 4 | Industrial cluster | First, population elements are essential factors affecting the governance mode of the innovation medium. Second, two of four technological regime proportions affect the innovation medium's strategic position. An innovation medium facing more technology prospects and appropriability is more likely to be innovation system oriented rather than production system oriented. Third, the governance mode contributes to the strategic position of the innovation medium. Government-dominated innovation media tend to have general-oriented strategic positions and equally stress production and innovation systems |
| STD 5 | Environmental sustainability and green readiness | The demand for green supply chains highlights the necessity for approximating green innovations in materials and processes and places additional problems in shifting green since the determination of what innovations are more valuable than others and which will be obsolete suffers the same ambiguity that companies concerned with high innovation levels do. Developing countries will only use these innovations if they have worked elsewhere. Also, each region requires funding for further development and implementation of these innovations to fit, especially in an affordable manner |
| STD 6 | Industry 4.0 compliance | Sustainability (E2), leadership management and support (O1), technology maturity (T1), compatibility (T2), and users' traits (I1) are more significant with the highest (R-D) values, which shows these determinants have a more significant impact on the whole model than other determinants |

(continued)

Table 6. (continued)

| Studies Code | Issues addressed | Major outcomes/key findings |
|--------------|---|---|
| STD 7 | Real-time feedback and design user-based modification for 3D fashion design | Application of computational design tool to use cases in fashion design shows that FlexTruss is a user-friendly and usable design in terms of feedback and design plasticity |
| STD 8 | Misalignment between design draft and real fashion | A novel D2RNet translates design drafts to authentic fashion items and shows promising performance in both shape preservation to original design drafts and creation of naturalistic texture details, and a novel R2DNet to solve its inverse task |
| STD 9 | Industry 4.0 readiness | The textile industry is a newbie in the Industry 4.0 implementation. Due to deficient digital elements in products and/or services, machine-to-machine communication, suitable strategies toward Industry 4.0 and its implementation plan, and poor ICT systems budget management |
| STD 10 | Decision support system for smart production | The study produced a decision support system for dyeing machine scheduling to integrate production information among individual systems and provide dyeing machine scheduling for maximising the utilisation |
| STD 11 | Treatment of dye waste water | The upconversion luminescence agent can emit five upconversion fluorescent peaks below 387 nm under 488 nm visible light excitation |
| STD 12 | There is a mismatch between apparel available in the market and existing body types for triangular female body-shaped Africans. No existence of a South African anthropometric database | Two models developed are reliable for three key rim body dimensions (bust, waist and hips) within the size chart for the full-figured, pear-shaped South African woman. The models confirm that the bust measurement is necessary for determining waist and hip body size measurements. Further, the bust measurement may be used to predict the apparel sizes by consumers. Size chart based on the standard "ideal" body shape cannot provide the full-figured, pear-shaped South African woman with the right fit of apparel |

(continued)

Table 6. (continued)

| Studies Code | Issues addressed | Major outcomes/key findings |
|--------------|---|---|
| STD 13 | The problem of textile batch dyeing scheduling arises due to the short product lifecycle and demand for smart fabric production | The proposed MSGA-H can solve the parallel batch processing machines scheduling efficiently and effectively. It is also robust |
| STD 14 | How to use augment reality technology to develop fashion design skills | There was a statistical significance between the performance of the two groups in favour of the experimental group that studied through augmented reality technology |
| STD 15 | Fashion marketability | In slow fashion operations, price and quality are two outstanding competitive criteria, whereas, Customer Relation Management and flexibility are the two outstanding competitive criteria in fast fashion operations. Competitive preferences may impact performance. Financial performance might focus on cost, flexibility, and quality; prioritising delivery and quality should be the focus for non-financial performance |
| STD 16 | Identifying the leading IoT platforms presently used by companies and verifying their versatility and the field of application | Industry 4.0 implementation demands a joint public sector action led by the government, businesses and the university. Only 23% of the companies surveyed do not use any platform to explore company data, although those realise the Industry 4.0 concept, while 47% of the companies confirmed utilising two or more platforms simultaneously in various business areas |

Appendix 2

See Table 7.

Table 7. References of the included studies

| Study Code | Full Reference |
|------------|--|
| STD 1 | Qureshi JA, Shaikh AM, Seaman C (2021) Leadership mindset and the fall of once giant family-run textile exporting businesses. <i>Glob Bus Organ Excell</i> 40:41–55. https://doi.org/10.1002/joe.22129 |
| STD 2 | Kawinakrathiti K, Phimoltares S (2014) A comparative study of CBIR descriptors on innovative application of fashion image. In: 2014 4th International Conference on Digital Information and Communication Technology and Its Applications, DICTAP 2014. IEEE, pp 164–168 |
| STD 3 | Miao Z, Lin W (2016) Based on goal programming model of optimization study of dyeing and finishing technology. In: Proceedings - 2015 International Conference on Intelligent Transportation, Big Data and Smart City, ICITBS 2015. pp 148–151 |
| STD 4 | Gong L, Jiang S (2011) Does one size fit all? Explaining the governance mode and strategic position of cluster innovation platform: A comparative case study of Zhili childrens garment cluster and Shaoxing textile cluster. In: PICMET: Portland International Center for Management of Engineering and Technology, Proceedings. IEEE, pp 1–15 |
| STD 5 | Ibrahim SE, Ahmed KH (2011) Key drivers for sustainable operations in developing countries: A textile case study from Egypt. In: PICMET: Portland International Center for Management of Engineering and Technology, Proceedings. IEEE, pp 1–8 |
| STD 6 | Ahmad S, Miskon S, Alabdan R, Tlili I (2021) Statistical Assessment of Business Intelligence System Adoption Model for Sustainable Textile and Apparel Industry. <i>IEEE Access</i> 9:106560–106574. https://doi.org/10.1109/ACCESS.2021.3100410 |
| STD 7 | Sun L, Li J, Luo D, et al. (2021) Fashion Design with FlexTruss Approach. In: Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems. ACM, New York, NY, USA, pp 1–4 |
| STD 8 | Han Y, Yang S, Wang W, Liu J (2020) From Design Draft to Real Attire: Unaligned Fashion Image Translation. In: MM 2020 - Proceedings of the 28th ACM International Conference on Multimedia. pp 1533–1541 |
| STD 9 | Dikhanbayeva D, Aitzhanova M, Shehab E, Turkyilmaz A (2022) Analysis of Textile Manufacturing SMEs in Kazakhstan for Industry 4.0. <i>Procedia CIRP</i> 107:888–893. https://doi.org/10.1016/j.procir.2022.05.080 |
| STD 10 | Ku C-C, Chien C-F, Ma K-T (2020) Digital transformation to empower smart production for Industry 3.5 and an empirical study for textile dyeing. <i>Comput Ind Eng</i> 142:1–11. https://doi.org/10.1016/j.cie.2020.106297 |

(continued)

Table 7. (continued)

| Study Code | Full Reference |
|------------|--|
| STD 11 | Wang J, Zhang G, Zhang Z, et al. (2006) Investigation on photocatalytic degradation of ethyl violet dyestuff using visible light in the presence of ordinary rutile TiO ₂ catalyst doped with upconversion luminescence agent. <i>Water Res</i> 40:2143–2150. https://doi.org/10.1016/j.watres.2006.04.009 |
| STD 12 | Afolayan OO, Zwane PE, Mason AM (2021) Statistical modelling of key body dimensions in developing the size chart for the South African pear - shaped women. <i>J Consum Sci</i> 49:52–63 |
| STD 13 | Huynh N-T, Chien C-F (2018) A hybrid multi-subpopulation genetic algorithm for textile batch dyeing scheduling and an empirical study. <i>Comput Ind Eng</i> 125:615–627. https://doi.org/10.1016/j.cie.2018.01.005 |
| STD 14 | Elfeky AIM, Elbyaly MYH (2021) Developing skills of fashion design by augmented reality technology in higher education. <i>Interact Learn Environ</i> 29:17–32. https://doi.org/10.1080/10494820.2018.1558259 |
| STD 15 | Sellitto MA, Valladares DRF, Pastore E, Alfieri A (2022) Comparing Competitive Priorities of Slow Fashion and Fast Fashion Operations of Large Retailers in an Emerging Economy. <i>Glob J Flex Syst Manag</i> 23:1–19. https://doi.org/10.1007/s40171-021-00284-8 |
| STD 16 | Sinisterra KVB, Mejía SM, Molano JIR (2017) Industry 4.0 and Its Development in Colombian Industry. In: 4th Workshop on Engineering Applications, WEA 2017, Cartagena, Colombia, September 27–29, 2017, Proceedings. pp 312–323 |

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