

# Experimental Research in Consumer Sciences



# Experimental Research in Consumer Sciences:

*Applications in Foods  
and Textiles*

By

Pinkie E. Zwane, Solomon W. Kidane,  
Lodrick M. Wangatia and Sifiso Vilakati

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## PREFACE

The focus of the book is to assist instructors in teaching both undergraduate and postgraduate Research Methods courses, to students majoring in food science and technology, textiles and apparel design and textile science and technology. It was realised that students enrolled in the above programmes had limited reference materials or books related to experimental designs in foods and textiles, and those available were expensive. Furthermore, in a quest to author teaching materials with subject specific examples in foods and textiles, it was befitting to embark on this book writing project.

This book is a product of four scholars from different professions (food process engineering, textile science, and statistics). Being an educational resource, each chapter commences with objectives and includes relevant examples in the disciplines on data entry, data analysis and data interpretation on studies likely to be conducted or studies that were conducted within the foods and textiles disciplines. It is believed that students or researchers would better relate to examples and understand how to use statistical packages. Each chapter has its own references.

The first chapter presents the historical background, and an explanation of the consumer sciences is presented as a backdrop because foods and textiles are sub-disciplines within the consumer sciences discipline. It also narrates the evolution of the discipline in Africa through the representation of one country from the four regions in Africa (east, west, central and south). The second chapter covers writing a research proposal. In the third chapter, basic statistics, and the application of statistics in foods and textiles are presented. The fourth chapter covers basic principles of experimental designs and commonly used experimental designs. Examples are also included in foods and textiles. The fifth chapter introduces statistical process modelling, and the optimization of commonly used response surface designs is presented with examples. Chapter six presents scientific report writing and the last chapter covers manuscript writing for publication.

Lessons learnt include professional gains, experienced in other parts of Africa, re-affirm the need for academics in Africa to contribute to the body of knowledge in the discipline. There is a need for better collaboration with

other African scholars to significantly contribute Afro-centric pedagogies and literature to our disciplines and sub-disciplines. Furthermore, teamwork is vital to accomplish goals. This book was accomplished through a real team effort. After an author had written a chapter, it was vetted by the co-authors for quality and improvement during the writing process.

Gratitude goes to the authors, Dr S.K. Thwala for sharing her experience in textbook writing for university teaching, Appreciation goes to the families of the co-authors for their support, to Professor L. Wangaita for acting as the secretariat for the book-writing team and for keeping tabs on everyone to meet the deadlines in our individual assignments.

The Authors

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# CHAPTER 1

## OVERVIEW OF THE CONSUMER SCIENCES PROFESSION

### **Learning Outcomes**

By the end of this chapter, you should be able to:

- Define the consumer sciences discipline from different viewpoints,
- Explain the Afro-centric evolution of the discipline,
- Describe the significance of foods and textiles in the discipline,
- Describe the work environments and professions that can benefit from the contents of this book,
- Define experimental research design, and
- Discuss the types and principles of experimental research designs.

### **Introduction**

The consumer sciences nomenclatures used earlier were domestic work or arts, domestic science, home science, home science education, living science, science of living and home economics. From the 1960s, new names of the profession emerged according to gender stereotypes of associating the profession with women, and it included human ecology, human sciences, life studies, household technology, and family and household education (Anyakoha, 2013; Balogun, 2009). Home economics terminology is still used in other parts of the world even to-date, such as in West Africa (Nigeria), Asian Pacific (Philippines) and some European countries (Finland). The introduction of earlier forms of the home economics discipline in the African continent was mainly through the colonisation of African countries by developed countries facilitated by European (British and French) and United States of America (USA) missionaries (Kittrell, 1965; Mberengwa and Johnson, 2004; Mberengwa and Mthombeni, 2012; Waudu, 1993).

Post-independence, in some African countries, training of professionals in the discipline was spearheaded by international developmental agencies like the United Nations, the Food and Agricultural Organisation and the United States Agency for International Development, whose foci were to improve the quality of life through international development (Kittrell, 1965). Opportunities that came with developmental agencies, provided funding to train locals who were to be instrumental in introducing domestic science in schools and training communities in home-making skills, in order to improve the quality of life for communities (Kittrell, 1965).

Ideas on the name change of the profession from home economics to alternative nomenclatures attracted extensive debates amongst scholars and practitioners in the profession around the mid-1960s. Nickels and Anderson (2001) posit that in the first half of the twentieth century, the discipline's attention was focused on the application of scientific principles to the management of the household, espoused by advocates like Ellen Richards, for a better quality of life. The focus was on teaching, research and public policy. In the last decade of the 20<sup>th</sup> century, there emerged increased enrolment in specialised areas of the discipline, resulting in diverse knowledge areas within each specialisation. That led to the renaming of the discipline by some institutions to family and consumer sciences, particularly in the United States of America (USA), and to human ecology in some Universities in the USA (Cornell University), Europe (Wageningen University and Research), and Southern Africa (University of Malawi). Some institutions in Southern Africa adopted the name consumer sciences for the discipline (University of Free State and University of Eswatini).

The consumer sciences nomenclature used in this book is defined to reflect existing nuances in the history of the profession in different institutions and countries but to have a key underlying understanding of the discipline that is improving the quality of life for individuals, families and communities. Presented definitions are from different institutions in the Southern African region and from global scholars with a contemporary, interdisciplinary understanding of the discipline:

- a) The Department of Consumer Sciences in the University of Free State in South Africa, defines consumer sciences as:

*a discipline that addresses various aspects of basic human needs. It explores an individual behaviour in relation to food and nutrition, clothing, textiles, housing, and food security. It includes courses and hands-on experiences in areas that include financing, nutrition, family and child development.* (University of Free State, 2021)

- b) Connecting with consumers, an international consulting company defines consumer science as:

*a discipline of understanding consumer choices, behaviours and preferences in relation to products (including media, packaged goods, communications, food/beverage user experience). The reason it is important for marketers and product designers to understand consumers, is so they can ensure that their promises meet consumer expectation and thereby make better and more appealing products for increasing sales. (Niedziela, 2016)*

- c) A definition proposed by Chanoweth, Eigsti and Stampfl (1984) cited by McGregor (2011) from the existing literature on conceptual clarity in consumer scholarship is:

*Consumer Sciences is an amalgamation of family economics and consumer economics. It is the interdisciplinary field that applies scientific method to the analysis of economic, social and political actions and interactions of consumers with the market and their use or consumption of those products and services through the exchange process. (p. 2).*

Although other countries in Africa use other names for the speciality, those definitions have not been included because the title of the book refers to the consumer sciences discipline. Highlights of the historical perspective of the home economics discipline in the African continent have been captured to give an appreciation of the impact the discipline has had on natives of the continent.

## 1.1 Evolution of the Consumer Sciences Discipline

Africa is divided into four geographical regions, namely West Africa, East Africa, Central Africa and Southern Africa. For the purposes of this book, only one country from each region will highlight the evolution of home economics/consumer sciences in the continent. Initially, the scope of the discipline was limited to the home and immediate community (Mberengwa and Mthombeni, 2012), but it expanded into the larger community that includes work environments, business environments and the educational advancement of the body of knowledge through systems theory and dynamic life development (Nickols and Anderson, 2001). The first country to present its historical perspective of the discipline, representing West Africa, is Nigeria. It was selected due to its easy access to historical documentation and rich achievements in home economics in the West African region.

### **1.1.1 Home Economics in Nigeria**

Home economics was formally introduced in Nigeria in the eighteenth century by early British missionaries (Catholic nuns) who arrived in Lagos in 1873. The subject was referred to as domestic science and the content included cookery, needlework and home craft. In 1927, a local school called Queen's College introduced the home economics subject, initially called home ecology and later it changed to home craft, domestic science and then post-independence, home economics. In 1933, mission schools in the northern states of Nigeria started domestic science programmes for girls. Early in 1960, home economics was introduced to the secondary school curriculum (Home Economics Professional Association of Nigeria, 2000).

The love for education in Nigeria, set it on a trajectory for diverse programmes in higher education. Curriculum design in Nigerian universities was influenced by ideas from Europe, the United States of America and Nigeria itself (Kittrell, 1965). The change of name for the profession from domestic science to home economics early in the 1960s was influenced by what was happening in the United States of America as there were opportunities for getting funding, grants and institutional support (Balogun, 2009). In 1962, the University of Nigeria Nsukka became the first higher institution to mount a degree programme in home economics. It remained the only institution offering home economics until 1973, when other tertiary institutions started offering the programme (Home Economics Professional Association of Nigeria, 2000). The course offerings in the curriculum, when it commenced, were food and nutrition, biochemistry, clothing and textiles, child development, nursery school education, home economics extension, art and family health (Kittrell, 1965). The next region to be discussed is East Africa, and Kenya has been selected to represent that region due to the abundant documentation and books authored by professionals in the discipline.

### **1.1.2 Home Economics in Kenya**

Home science was introduced in Kenya as a subject for women and girls in 1904 by the British through missionary schools at Kikuyu and became part of the normal school curriculum (Wahome, 2005). In 1955, home science was examinable in grade eight; but after two years (1957), it was removed from the primary education syllabus because it did not achieve its goal of preparing young women for their roles as future wives (Sigot, 1987). It continued being offered in schools but was not examined and in 1967, the



syllabus was revised, and the name of the subject was changed from home science to domestic science (Gachathi, 1976).

Between 1975 and 1984, domestic science was offered in secondary schools and comprised five major areas, which were home management, foods and nutrition, clothing and textiles, consumer education and childcare. The curriculum in teacher training colleges was also revised around the same period because only girls were enrolled in schools (Wahome, 2005; Mugenda, 1995).

Training at the tertiary level occurred in the mid-1960s. There was a diploma course in home economics at a college in Nairobi which was affiliated to the University of Manchester in England. The curriculum focused on dressmaking, cookery, budgeting, laundry, sewing and housewifery. The programme was run by five European teachers. Ten Kenyans were identified and sent to the USA for their first-degree training because the college had intentions of upgrading the diploma programme to a degree programme (Kittrell, 1965). It was after the revised curriculum in 1985 that men started enrolling in the home economics degree programme at Kenyatta University (Wahome, 2005; Mugenda, 1995). The third region to be discussed is Central Africa, and Congo was selected due to the availability of documentation in English through the influence of English authors in that country.

### **1.1.3 Home Economics in Congo**

Prior to the influence of American missionaries, there were missionaries from other European countries including Belgium, who arrived in Congo and operated small schools in the 1930s; but home economics in Belgian Congo was introduced in an impactful manner by two female Southern Methodist missionaries (Lorena Kelly and Catherine Parham) from the United States of America (Richards, 2017). The two women from America embraced and implemented an ideology of “Christian Womanhood”, which embodied a traditional and modern understanding of femininity, and religion that led to a cultural and identity transformation amongst Tetela women in Belgian Congo. Kelly and Parham both taught at the normal school (for training would-be teachers) and the Bible school (for training pastors) (Richards, 2017).

Parham arrived in Belgium Congo in 1931 and established a school called the girls’ home at the Tunda station (Richards, 2017). The school was home for the girls till they got married (Parham, 1933). Another girls’ home was

built at the Tunda station after a higher enrolment of girls was realised. Content of the curriculum in the girls' school covered basic domestic lessons, infant care, housekeeping and cooking (Kelly, 1938). Kelly joined Parham in 1936 and was stationed at Wembo-Nyama station, where a girls' school was built in 1938.

By the 1950s, full-scale home economics schools were thriving and by 1957, sixty women were enrolled in home economics schools (primary schools) at the Lodja station. After graduation from the home economics schools, women could attend and graduate from the normal schools and become teachers for the home economics schools (Parham, 1955). A textbook for the home economics school in the local language on the three areas of the curriculum was published in 1961. In 1960, missionaries evacuated Belgium Congo when the country gained its independence. At that time, there were no women to pursue degrees in home economics, but a six-year secondary school education based on the European academic pattern had been established in preparation for mounting a degree programme at university level. The first group of 38 girls graduated from the secondary school in 1966.

The Methodist church continued to actively work on a home economics programme for higher education from the early 1960s. The plan to establish a faculty of home economics was conceived. The faculty was to be located at the University of Stanleyville, where semi-technical programmes were to be housed. The proposed curriculum had three subject areas: a) general cultural courses, b) specific home economics subjects, and c) supporting courses. Two Congolese women were sent to the USA for further training to attain a BS degree in home economics. One of them was trained at Howard University and graduated in 1966 (Kittrell, 1965). The last region to be discussed is Southern Africa, and Eswatini was selected because the authors of the book reside in the country.

### **1.1.4 History of Home Economics in Eswatini**

Home economics in Eswatini was introduced by missionaries in 1936 and the subject was called domestic science. The purpose of education or missionaries was to make students aware of western culture and to effectively prepare them to participate in the market economy (Hay, 1989). Two primary mission schools in the Shiselweni region and two in the Manzini region (one school in the latter region was government owned) held domestic science classes in the 1930s (Myeni, 1992). After an introduction of the subject in schools, the Swaziland Conference of Churches decided to

initiate teacher training for schools. Margaret Letta from Scotland worked on the required curriculum and pioneered a class of trainees in 1936 (Myeni, 1992).

Mrs Stubbs developed domestic subjects in Swazi primary schools in 1946 and was placed in charge of the domestic department for both primary and secondary education in 1955. As a part of progression to the primary schools that offered domestic science courses, Evelyn Baring was the first school to offer domestic science at secondary level in 1951 and matric (O) level in 1955 (Myeni, 1992).

As the number of matric classes increased, there was an increased demand for trained teachers and this created a need for trained teachers locally (National Education Review Commission, 1985). From the 1950s, Eswatini relied on the Nazarene Teacher Training College and the Mbuluzi Housecraft Centre for training primary school teachers and domestic science demonstrators locally (Dlamini, 1983).

Based on limited training institutions for teachers, a need for local training was realised in 1960. The Swaziland Agricultural College and University Centre (SACUC) started offering (in 1966) the second year of the home economics certificate programme; trainees did their first year at the Mbuluzi Housecraft Centre and then proceeded to the SACUC (University of Botswana, Lesotho and Swaziland Calendar, 1969-1970). The SACUC continued to offer the one-year training towards the certificate programme till 1968, after which the programme was phased out in 1969.

In an effort to reach more young girls who were not in the formal education system, government established vocational training centres in 1973, targeting school-aged women or girls. Subjects taught at the centres included home-making skills and self-help courses to enable graduates to be self-employed. The government then further provided a training institution, the William Pitcher College established in 1970, offering a certificate programme in domestic science in 1974, and later offered a diploma in 1989 (Myeni, 1992).

The home economics extension service started in the 1940s with an expressed need by wives of farmers who wanted to be trained in home-making skills like cooking, handicraft and sewing. Training was done by domestic science demonstrators, some of whom had received training in South Africa (Myeni, 1992). In 1963, the first domestic science demonstrator was hired, who visited rural women to conduct demonstrations on home-

making skills and crafts. Zenzele Women's Associations were established to share experiences and to better learn the subject matter of home economics (Myeni, 1992).

In 1965, the Ministry of Agriculture consulted the Food Agricultural Organisation (FAO) for technical assistance. Through a consultant, community nutrition education was introduced and the need for a school feeding programme was initiated with assistance from the FAO and other United Nations Agencies. The first local home economics officer appointed to be in-charge of the section in the Ministry of Agriculture received a scholarship to pursue a first degree abroad in 1967. Upon her return from training overseas, she was assigned to be in-charge of home economics in the Ministry of Education and was instrumental in starting a Home Economics Association. An increased need for education was realised in rural communities, hence rural educational centres were established in 1976 to offer non-formal education for adult women and unemployed rural youth. The goal of the eight established centres was to assist rural development in the education of all communities around the centres (Myeni, 1992).

With an emphasis on promoting nutrition education, the Swaziland Nutrition Council was established through an Act of Parliament in 1945; a nutritional study was undertaken to justify the need for the office in 1983 by the Ministry of Agriculture and persons were employed in 1989. The Nutrition Council is an inter-ministerial body on food and nutrition policy and programmes. This organ fell under the Home Economics Section in the Ministry of Agriculture, but later housed under the Ministry of Health (Myeni, 1992).

At the tertiary level, the SACUC established the Home Economics Department in 1974, and introduced a diploma programme in home economics education and home economics extension in the same year (Dlamini, 1983). The extension programme was terminated in 1979 due to a saturation of the job market. From 1980 to 1999, only the home economics education two-year programme was offered. In 1993, the department introduced a four-year BSc degree programme in home economics education to train mainly teachers for the Ministry of Education.

In 1999, a two-pronged programme, namely BSc in home economics and BSc in home economics education, was introduced. The former degree was designed to train professionals for private sector employment as well as extension. It constituted a three-year diploma programme and an additional two years for the degree programme. In line with developments in the

Faculty of Agriculture, options were introduced for the BSc home economics degree. After the three-year diploma, a student could opt for textile, apparel design and management (TADM) or food science, nutrition and technology (FSNT). Another major development faculty-wide, was the replacement of the five-year BSc programmes with four-year BSc programmes, which started in the 2006/2007 academic year. With the global winds of change in renaming the discipline, the Department of Home Economics was changed in 2009 to the Consumer Sciences Department. The University of Swaziland, now called The University of Eswatini, approved the department to be upgraded to a Faculty of Consumer Sciences in 2016.

## **1.2 Significance of the Food and Textile Specialisations**

The introduction of specialisations in the home economics/consumer sciences from the late 1990s to the early 2000s in different regions of the world, was triggered by the need for the profession to increase its student enrolment at the tertiary level in other regions and to assert a separate identity that required different skill sets from related disciplines like agriculture. The new identity was necessary to facilitate growth in programme offerings for the better marketability of graduates to potential employees and for business start-ups for entrepreneurs. It also meant autonomy in curriculum design for programme offerings using tailor-made courses to specifically benefit students enrolled in the discipline. In some universities, the growth has led to the establishment of Home Economics/Consumer Sciences Faculties.

With the challenge of unemployment of university graduates, emphasis in most African universities is on training students on entrepreneurship to become innovators and start businesses instead of being employees. Quite a number of universities in Africa that are affiliated to the Regional University Forum (RUFORUM), a network of African universities aimed at strengthening capacity building in agriculture for improved food production and food security, have received funding with the aim of starting entrepreneurial hubs or incubators to inculcate business acumen in graduates and for augmenting dwindling funding streams from governments to universities in general. The two areas in the discipline with potential to participate in business projects are foods and textiles. Graduates and researchers in the aforementioned areas need a specific skill set for value addition in food or textile processing operations to contribute towards improving the quality of family lives.

Specialisation in the areas of foods and textiles in the local context was also triggered by the needs of the private sector that required graduates with specific competencies that were beneficial to companies and non-governmental organisations. With the need for advancement in training and specialisations, researchers have experienced challenges in applying and executing experimental research designs in their research projects. Available reference materials in the form of textbooks on research methodology are mainly in education, social and behavioural sciences, pure statistics and pure sciences. Scholars in consumer science related areas have made efforts to author books and these include *Methods in Consumer Research Volume 1 and 2*, *Statistics for Textile Engineers*, and *Statistics for Textile and Apparel Management* to cater for researchers in this discipline.

It has been further realised that to aid growth, the discipline has inadequate reference materials in experimental research tools applied in an integrated approach to the consumer science discipline, and there is no provision of examples in experimental designs used in foods and textiles. The authors then decided to write this book, which provides the needed references for using more experimental research designs in a transdisciplinary approach, related to product development due to the emphasis on value addition in entrepreneurial projects in an African context. The transdisciplinary approach involves the intellectual generation of knowledge beyond academic disciplines or boundaries and across sectors external to the university for the benefit of society (McGregor, 2016). The need is further necessitated by researchers in the two areas of specialisation that require higher scientific research tools to produce innovative products and solutions, in the research and development landscape, to address existing concerns of humanity. The next section will address relevant professions in foods and textiles that would most likely use experimental research designs.

### **1.2.1 Food professions that utilise experimental research designs**

There is a plethora of careers in the food industry, but the focus will be on professions that would benefit from the use of experimental research designs. The three career titles discussed below include a quality or technical manager, a quality assurance technologist, and a product development manager (William Reed Business Media, 2021).

**a) *Quality/Technical manager***

A Q/TM should have a good understanding of quality management systems and the ability to identify improvements and develop operation systems. The manager leads adherence to specifications of food products or quality management or processes and new product development, in addition to overseeing technical compliance to safety standards in a dynamic manufacturing establishment; takes ownership of non-conformances from processing and customer specifications and investigates and resolves customer complaints; develops a quality culture to ensure that targets are achieved and standards are continuously improved; provides technical support for production trials and delivery of innovation projects; maintains HACCP (Hazard Analysis and Critical Control Points) and TACCP (Threat Analysis and Critical Control Points) as tools for identifying and controlling risks throughout the production site; assists in driving compliance to the manufacturing standard and providing expertise and guidance on the implementation of industry and customer standards; assesses the regulatory compliance of proposed product optimization interventions, and assists in conducting external audits and customer visits. In addition, the manager works closely with the supply chain, marketing and production departments to introduce new products.

**b) *Product development manager***

The manager leads the development of new products, the adaptation of existing products and the creation of tailor-made products based on customer requests. The job profile involves developing new ingredients from raw materials and mixing inputs to produce samples; working with internal or customer requirements from brief to development of samples; using software to manage the new product development process and formulations; developing and managing laboratory systems and processes; managing the testing of samples internally and externally; costing samples as required, and liaising with the quality assurance department in the development of specifications.

**c) *Food technologist***

The technologist works closely with the technical manager and is involved with technical duties from maintaining the supplier approval matrix, writing product specifications, checking product packaging and creating new product labels, arranging and conducting taste panels, helping to maintain quality management, and conducting traceability exercises, factory audits and audits of finished product.

**Example 1-1:** *The different professionals (product developers, food technologists and quality/technical managers) use the experimental research approach in identifying and screening factors that potentially influence the quality attributes of food products. Experimental designs (e.g., Plackett-Burman, fractional factorial) are used at the early-stage product development by these professionals. Once the factors are screened and the most important factors are identified, there is a need to optimize the screened factors to set them at levels that give the best results using multi-criteria optimization techniques. For this purpose, other experimental designs like response surface designs (central composite designs, factorial designs, Box-Behnken) are used by product developers and technologists.*

### **1.2.2 Textile professions that use experimental research designs**

Careers in textiles can be categorised under fashion/textile merchandising, apparel design and production, media work, textile production, and textile research. The focus of this book will be on the production of textiles or apparel and textile research. The five careers discussed are textile technologist, colour technologist, textile designer, textile quality assurance manager, and product designer (AGCAS Editors, 2021).

#### **a) *Textile quality manager***

A fabric quality manager develops, implements, communicates and maintains a company's quality assurance systems and policies in compliance with customer requirements to avoid defective goods; ensures mill partners are held to the highest quality standards; works with the fabric mills to establish the best quality system and holds them accountable to these standards and key performance indicators; develops fabrics according to the buyer's requirements; foresees fabric quality issues, and provides solutions to overcome them; coordinates with the knitting, dyeing, finishing, merchandising, garment production and other related departments in product manufacturing; executes economic and production plans for effective batch scheduling based on dyeing timelines; and checks dye laboratory recipes to ensure problem-free dyeing, and gives real-time feedback to respective departments to minimise loss of quality and time.

**Example 1-2:** *A dyeing factory has orders to supply school uniforms to a school. The school uses a colour which the factory stocks, but to arrive at the particular shade preferred by the school, the factory must vary several dyeing parameters; some of these have a great influence on the shade required and others contribute to other factors of interest like durability and*



*cost. To be able to develop satisfactory products as requested by the school, the factory needs to develop a dyeing recipe using a combination of various parameters at varying levels. This can be effectively done by experimental design to reduce the amount of work and optimize the results.*

**b) Textile designer**

A textile designer creates two-dimensional designs that can be used, often as repeat designs, in the production of knitted, woven and printed fabrics or textile products; works in both industrial and non-industrial locations, often specialising in interiors or fabrics for functional contexts like fireproof materials within the textile industry; works out design formulae for a group of samples; assesses and approves completed items and production standards; uses specialist software and computer-aided design (CAD) programmes to develop a range of designs; is involved with the science and technology of colour application and its subsequent performance, making sure reproduction is accurate, application is even and the colour has durability; experiments with fabric and texture in developing new design and production techniques and textile technology; and maintains up-to-date knowledge of designs and develops new design concepts, and works in various sectors of the manufacturing industry.

***Example 1-3:** To develop a warm and light fabric for use in making winter clothing, a textile designer needs to consider various factors to weave the fabric: the fibre type used, yarn count, weave pattern, ends per inch and picks per inch. The designer needs to make an effort to maximize the intended warm and light utility at minimum cost. Some of the factors may have an interaction effect. Experimental design may be applied.*

**c) Apparel Designer**

The designer improves the usability of everyday items by creating new designs and enhancing existing ones; creates a range of items, from everyday products; improves the design and usability of an item using an understanding of technology, materials and manufacturing methods; works on new products or improves existing ones; identifies the suitability and availability of materials; produces detailed, final hand drawings and specifications using dedicated computer software (CAD) to produce design specifications, including parts' lists and costings; makes samples or working models using computerised prototyping equipment; tests the design concept by the computerised modelling or physical hands-on testing of models; researches materials, processes or market requirements; and arranges

meetings and liaises with engineers and other departments, including marketing, to discuss and negotiate appropriate production processes, costs and commercial issues.

***Example 1-4:** To manufacture apparel that is comfortable to the wearer, particularly for functional wear, different fabric structures with breathability qualities may be used, and by using a sweating manikin, the apparel design expert may determine which fabric is more comfortable when worn by the wearer.*

**d) Textile technologist**

A textile technologist has a hands-on role in selecting and testing the ideal fabric or material for a product; works with a variety of fabrics, both man-made and natural fibres, as well as leather, fur, metals and plastics; sources fabrics or textiles that are fit for purpose and carry out quality control tests; and works on the development of products, improving production efficiency and quality, while liaising with those involved in the production process.

***Example 1-5:** A technologist may want to develop a new textile fabric with a hydrophobic property by surface finishing the fabric with zinc nanoparticles. The following process parameters have an interaction effect and need to be optimised to achieve the best results: the concentration of hydrophobic compounds and dye concentration, pressure, and temperature. Experimental design can be used for the optimization of the process.*

### **1.3 Experimental Research Design**

There are divergent views on the merits and demerits of experimental research designs. Justification for either view will not be discussed in this book. Cash, Storga and Stankovic (2016) posit that experimental research designs provide objective measures of phenomena most notable in the natural sciences. Experimental designs further provide valuable empirical data that can be augmented by non-experimental or qualitative research which is more meaningful in the social and human sciences. Experimental designs in the context of this book contribute to technological innovations and technical understanding of the physical and life sciences (Radder, 2003).

The definition that augers well in this book is that experimental research design is an approach in research where variables are manipulated in a

controlled environment. It determines the cause-and-effect relationship between variables and helps in knowing the testing outcomes (Bouchrika, 2021). There are three basic types of experimental research design, which are true experimental design, quasi experimental design and pre-experimental design. A summary of the designs is presented in Table 1-1.

**Table 1-1 Basic types of experimental design**

Type	Description
<b>True experiment</b>	Participants are randomly assigned to treatment conditions including a control
Control	Extraneous variables are controlled through randomization and comparison with control
Demonstrates	Cause and effect, and has high quality of evidence
<b>Quasi experiment (natural experiment)</b>	Participants are non-randomly assigned to treatment conditions
Control	Extraneous variables are controlled through a comparison with control conditions
Demonstrates	Correlation
<b>Pre-experiment (pseudo-experiment)</b>	Participants are randomly assigned to treatment conditions but no control
Control	Extraneous variables are mitigated through a comparison with a non-treatment group (pre-design and post-design)
Demonstrates	Correlation, low quality of evidence

Adapted from Cash, Stonkovic & Storga (2016)

Experimental designs have guiding principles in their application and also determine the type of design used in a study or research project. According to Dafaallah (2019), the three basic principles that are crucial in experimental research designs, which are discussed in more details in chapter 5, are:

- a) Control – allows for certain restrictions on randomization in blocking or grouping in order to reduce experimental error.
- b) Replication – when a treatment is repeated two or more times in the experiment to improve precision by reducing experimental error.

- c) Randomization – the assignment of treatment to experimental units to prevent biasness.

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