



TWELFTH EDITION

TEXTILES

SARA J. KADOLPH SARA B. MARCKETTI

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Textiles

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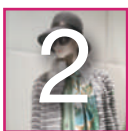
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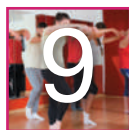
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Philosophy of This Book

Textiles provides students with a basic knowledge of textiles so that they understand how textiles are produced and how appropriate performance characteristics are incorporated into materials and products. With this knowledge, they have the foundation needed to make informed decisions regarding textile materials and products and to communicate effectively with team members in the workplace as well as with suppliers, contractors, and buyers. A solid understanding of textile components (fibers, yarns, fabrics, and finishes), the interrelationships among these components, and their impact on product performance enables them to fulfill day-to-day responsibilities in many careers in the textile, apparel, and interior segments of the global textile complex.

Serviceability of textiles and textile products is the fundamental principle emphasized throughout the book. Discussion focuses on the contributions of each component as it is incorporated in or combined with other components in a textile product. Interrelationships among the components is another critical component. Basic information regarding how each component is processed or handled helps in understanding product performance and cost. Production of textiles is a complex process dealing with a wide variety of materials and techniques. To understand textiles, students need a basic understanding of the choices and technology involved.

This book will help students:

- use textile terminology correctly;
- know laws and labeling requirements regulating textile distribution;
- understand the impact of production processes and selection of components on product performance, cost, and consumer satisfaction;
- describe major forces that drive product and process developments;
- identify fiber type, yarn type, and fabrication method;
- predict fabric or product performance based on a knowledge of fibers, yarns, fabrication methods, and finishes in conjunction with informative labeling;
- select textile components or products based on specified end uses and target market expectations for performance and serviceability;
- select appropriate care for textile products;
- describe major issues related to the sustainability of textiles and their production, use, care, and disposal; and
- develop an interest in and appreciation of textiles.

Understanding textiles cannot be achieved only by studying this book; it also requires working with fabrics. Numerous learning activities included in the

chapters make use of fabric swatches. The numbers in the activities refer to the swatches in the Basic Swatch Kit available with this book.

Organization of This Book

Each section of the book focuses on a basic component or aspect of fabrics and textile products or on general issues important to the use of, production of, or satisfaction with textile products. Sustainability issues are included in almost every chapter. Each section is complete and can be used in any order desired. The four main sections follow the normal sequence used in the production of textiles: fiber, yarn, fabrication, and finishing.

The first section of the book introduces the study of textiles and the global textile complex and approaches product development from a textile perspective. Section II focuses on fibers and their production, serviceability, effect on product performance, and use. Smart textiles and nanotechnology are included. Section III focuses on yarn production, yarn types, the relationship of yarn type to product performance and serviceability, sewing and embroidery threads, and rope. Section IV examines fabrication methods. These chapters are organized by basic fabrication method, standard or classic fabric names and types, and the relationships between fabrication and product performance. Areas that were confusing have been clarified. Section V deals with finishes, grouped by type or effect. Dyeing and printing are also included, as well as problems that consumers and producers experience with dyed or printed fabrics. Section VI deals with other issues related to textiles. One chapter focuses on care of textile products, cleaning compounds and processes, and associated sustainability concerns. Another chapter investigates legal and sustainability concerns. The final chapter discusses career opportunities requiring knowledge of textiles and has been extensively revised to reflect the ever-changing career opportunities in the textile, apparel, and interior design industries.

This book assumes that the student requires basic information regarding textiles in order to perform professional responsibilities and communicate with other professionals in an intelligent and informed manner. Hence, the book is designed to be of use as a textbook and to become a valued component of a professional's reference library. Key terms are defined in both the text and the glossary. The glossary includes more than basic or classic fabric names as well as a pronunciation guide. Fiber modifications, finishes, and terminology related to performance have been incorporated. The extensive index will help individuals locate information needed for class or on the job. Appendix A lists fiber names in several languages that may be encountered in the global textile complex.

Appendix B lists fibers that are not produced in the United States. Appendix C lists selected trade names for fibers, yarns, fabrics, finishes, and cleaning procedures. Appendix D is a map of the world that students can use to understand the global nature of the textile complex. Appendix E provides definitions from the Federal Trade Commission for care label terms. A shorter list of such terms is in Chapter 20. Appendix F provides stain removal guidelines.

Features of This Book

Instructors and students have always liked this book's summary and reference tables and charts, the presentation of information in a clear and consistent fashion, the emphasis on serviceability, and the numerous illustrations, graphics, and photographs. These aspects are strengthened with this revision.

Although the basic content and flavor of *Textiles* remain intact, the changes help students recognize and focus on the most important material. Objectives and key terms for each chapter were updated so that students will be able to identify and understand the major concepts. After reading and studying each chapter, students should be able to define each term in the key terms list and describe how terms relate to each other and to the chapter content. Additional review questions provide students with an opportunity to test their level of understanding, focus on key concepts or applications, and integrate the information. Updating the list of readings helps those students who like to investigate topics beyond the scope of the book. Many of these readings are technical in nature. There are a few articles on textiles in the popular press, but these often include little substantive information. Hence, the most valuable articles and books tend to be those written from a technical perspective.

Major Changes and Additions

The emphasis in this revision has been on updating and adding material where new processes or concerns have developed in the professional workplace, in the global textile complex, or among consumers. In almost every chapter, a discussion of the local fiber movement was added. Terminology incorporates an industry perspective so that professionals can understand and communicate with other professionals. The pronunciation guide included with some words in the glossary will help professionals pronounce and use terms correctly. The expanded index facilitates the book's use as a resource by professionals who need to locate information quickly regarding a specific term, process, or product. Color photographs and diagrams make the text more interesting and concepts easier to understand.

The book continues to focus on the three major end uses of textiles: apparel, interiors, and technical products. However, many changes have been made in the text. Technological advances and new industry and societal concerns that have arisen or have increased in importance since the last edition are included. Several topics have been reorganized to more closely represent industry practices or to enhance learning.

The chapter on finishing combines mechanical and chemical finishes—an anathema to the textile purist, but an approach that works well with students. Nanotechnology and changes in chemicals and processes reflect the ever-increasing interest in sustainability.

The chapter on career opportunities has been extensively revised to help students understand careers and how they will apply their knowledge of textiles and textile products in their professional work. It should help students gain a better understanding of careers and how professionals interact with each other. Although this chapter may not be assigned in a beginning textile course, students might read the chapter on their own to explore career possibilities and use the information when considering career options other than those that are most obvious to the consumer.

Many more Learning Activities and a new case study are included with every chapter. Many Learning Activities make use of the Basic Swatch Kit that is available to purchase with this book. Other Learning Activities allow students to discuss topics in small groups, explore current events or topics, or use the textiles they are wearing or have around them as learning tools. Most of these activities are independent of additional resources. Key concepts for each chapter are emphasized. Review questions included at the end of each main section of the book encourage students to connect textile components to product characteristics and performance.

Supplements

Instructor Resources

- **Instructor's Manual** that includes an updated outline of the material for each chapter, a revised list of suggested activities, and bank of test questions in a variety of formats.
- **PowerPoint Presentation** for use in lectures or as a supplement to class activities.
- **Online Instructor's Resource Center** to access supplementary materials online. Instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc, where you can register for an instructor access code. Within 48 hours after registering, you will receive a confirming e-mail, including an instructor access code. Once you have received your code, go to the site and log on for full instructions on downloading the materials you wish to use.

Student Resources

- **Swatch Kit** that is packaged in a three-ring binder includes over 100 swatches, a master list of the fabric swatches (with fabric name, description, and fiber content), heavyweight mounting sheets, linen tester/stitch counter, and a Textile Companion CD with more than 1,300 fabric images.

Acknowledgments

We used the comments and contributions of many students and colleagues in preparing this revision. Students' comments help the most in evaluating the approach, wording, and style of presentation, and therefore we appreciate hearing from any student or faculty member about the book. Both positive and negative comments are incredibly helpful and invaluable in revising the book. We would especially like to thank Chunhui Xiang and Amanda Lensch of Iowa State University for their helpful suggestions. Thanks to reviewers for their comments and suggestions: Nancy Asay (Missouri State University), Marie Botkin (California State Long Beach), Debra Hillen (Johnson County Community College), Renee Young (Fullerton College), and Sara Sunderlin (North Dakota State University). Sara Kadolph would like to personally thank her sister Lora Camacho, who helped keep her sane while working on this edition. And Clementine, Silkie, and Franklin for the reminder that cats need to be fed and petted every day! Sara Marcketti would like to thank her family for the time and space and Sara Kadolph for the opportunity to work on this book.

Revising this book is always an exciting challenge, as it allows the opportunity to explore the textiles literature in more depth than university responsibilities usually allow. We hope that this book hooks you on textiles as the third edition of this book did for Sara Kadolph and the ninth edition did for Sara Marcketti.

Sara J. Kadolph

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About the Author

Sara J. Kadolph is a retired professor emeritus of Apparel, Merchandising, and Design at Iowa State University in Ames, Iowa, where she taught for 30

years. She taught several courses related to textiles: chemistry, dyeing, quality assurance, and conservation. Dr. Kadolph is the recipient of numerous teaching, advising, and professional awards including teaching excellence awards from the International Textiles and Apparel Association, Iowa State University, and the Iowa Association of Family and Consumer Sciences. She was the inaugural holder of the Donna R. Danielson Professorship in Textiles and Clothing. She is a Fellow of the International Textiles and Apparel Association and a Wakonse Fellow.

Dr. Kadolph has consulted with companies in the textile complex to solve quality problems, educate product development/design teams, select materials, assess textile performance, write specifications, and develop quality assurance programs. Her teaching and research scholarship has been published in the *Clothing and Textiles Research Journal*, the *Journal of the Society of International Natural Dyeing*, the *Journal of the Korean Society for Clothing Industry*, *The Journal of Consumer Education*, the *Journal of Family and Consumer Sciences*, the *International Journal of Clothing and Science Technology*, and others. Her *Textiles* book with Pearson Education is used in colleges and universities throughout the world.

Sara B. Marcketti is an associate professor in the Apparel, Merchandising, and Design Program and Associate Director of the Center for Excellence in Learning and Teaching at Iowa State University. She teaches courses in textile science, history of dress, and creative thinking and problem solving. Dr. Marcketti is the recipient of numerous teaching, research, and professional awards including teaching excellence awards from the International Textiles and Apparel Association, Iowa State University, and the Costume Society of America. She is a Wakonse Fellow.

Dr. Marcketti's teaching and research scholarship has been published in the *Clothing and Textiles Research Journal*, *Dress*, *Textile History*, the *Journal of Family and Consumer Sciences*, and others.

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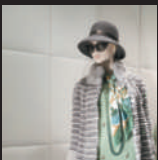


Section I

INTRODUCTION TO TEXTILES



1 Introduction



2 Product Development from a Textile Perspective



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Introduction

CHAPTER OBJECTIVES

- To identify the value of developing a professional knowledge of textiles.
- To recognize the diversity in textiles and textile products.
- To determine how textile apparel, interior, and technical products enhance quality of life for individuals, communities, and society.
- To describe the global nature of the textile complex.



1

Fashion and textiles continue to be at the forefront of innovation. From evidence of weaving and dyeing technologies of about 30,000 years ago to the latest developments in high-tech health monitoring, textiles have always been at the frontier of invention and one of the world's major industries. Indeed, while the global apparel industry continues to change with new technologies such as 3D printing, increased automation through computerized manufacturing processes and equipment, and the phenomenon of social media that is reshaping nearly every industry, the need and desire for textiles remains constant. Whether it is consumers desiring a new fashion, soldiers needing uniforms and equipment for ballistic protection and heat and moisture management, or textiles that help protect the environment, knowledge and understanding of textiles is key! Throughout this book, you will learn about all of the amazing textiles and their properties and innovative research in the industry, to help you as a student, consumer, and future professional within the global textile complex.

This book is divided into six sections taking you through the entire life cycle of a textile from product development through materials, fabrication, finishing, and care and disposal from a legal, sustainable, and environmental lens. The interdependent elements of fibers, yarns, fabrics, finishes, and coloration, found in most textiles, contribute to everything about the product: aesthetics, durability, how it is cared for, cost, appearance retention, safety, function, and comfort of these products.

The first section is divided into two chapters. Chapter 1 introduces the study of textiles by defining terms, providing examples of textile products, surveying the diversity of textiles, and describing the importance of the textile complex to the global economy. Chapter 2 describes characteristics of textiles, the manner in which textiles and textile products are developed and used, and how consumers assess their satisfaction with them.

Students may find much of the terminology used in this book new, with terms and facts needing to be memorized. It takes time and effort to understand and recognize the differences among fibers, yarns, fabric structures, finishes, and coloration methods. You will need to examine closely many fabrics in order to develop this ability.

Professional Importance of Learning Textile Science

Evaluation and determination of the similarities and differences among fabrics is tantamount to any career in the textiles global complex. Imagine, for example, designing children's sleepwear out of woolen herringbone, producing silk swimwear, or merchandising a tent made from mesh. Clearly not the proper choices for the end uses! Furthermore, the wide variety of products produced and sold within the global textile complex has created challenges in the selection of apparel and interior textiles. Many items look alike but their performance and care differ significantly. Without specific knowledge of textiles, it is impossible to know what factors are important for specific end uses. Knitted fabrics look like woven fabrics, vinyl and polyurethane films look like leather, and acrylic and polyester fabrics look like wool. Traditional cotton fabrics may be polyester or polyester/cotton blends. It is the responsibility of consumers to ensure the products purchased are appropriate for the end use and for those in the global textile complex to ensure consumer trust is not damaged by poorly performing textile products.

Textiles and Textile Products

The definition of several key terms is a logical starting place to understand what textiles are with respect to both personal and professional use.

Polymer A very large molecule made by connecting many small molecules together. Almost all fibers are polymers made of organic materials, but some polymers are formed into thin films and used as textiles. For example, vinyl upholstery is a film, often applied to a more traditional textile knit or woven material for added durability.

Fiber Any substance, natural or manufactured, with a high length-to-width ratio possessing suitable characteristics for being processed into fabric; the smallest component, hairlike in nature that can be separated from a fabric. Fibers can be absorbent (like cotton and rayon), stretchy (like spandex), warm and bulky (like wool), or very strong and abrasion resistant (like nylon and polyester). (See Figure 1.1.)

Yarn An assemblage of fibers that is twisted or laid together so as to form a continuous strand that can be made into a textile fabric. Yarns can be used to make a fabric that is smooth and slick like satin or soft and fuzzy like brushed denim. (See Figure 1.1.)

Fabric A flexible planar substance constructed from solutions, fibers, yarns, or fabrics, in any combination. (See Figure 1.1.) Fabrics range from lightweight and sheer chiffon scarves to heavy and sturdy denim to rigid and firm carpeting to technical products such as erosion control and medical tapes. (See Figures 1.2, 1.3, and 1.4.) Cloth and material are common synonyms for fabric.

Textile A term originally applied only to woven fabrics, now generally applied to any flexible material that is composed of thin films of polymers or of fibers, yarns, or fabrics or products made of films, fibers, yarns, or fabrics.

Gray goods (grey or greige goods) Any fabric that has not been finished. Consumers rarely see gray goods, except for home sewers and quilters who may work with muslin.

Coloration Any dyeing or printing process used to add color with dyes or pigments to a textile. Coloration adds interest and fashion appeal to apparel and interiors. (See Figure 1.1.)

Finish Any process that modifies appearance or enhances performance of gray goods (unfinished fabric). Some finishes make the fabric more comfortable such as brushing velveteen to produce the soft surface. With other finishes, the consumer cannot determine the presence of a finish. For example, a pair of cotton slacks may have a stain-resistant finish that makes stains easier to remove, but the consumer will not be able to see the finish and will only know of its presence if such information is included on labels or tags. (See Figure 1.1.)

Soft goods Products constructed of textiles and other flexible materials including apparel, interior textiles, and technical textiles.

Apparel Clothing and accessories made from flexible materials.

Interior textiles Also known as *interior furnishings* or *home fashions*; describe textiles and textile products used in the home and other building interiors for functions such as absorbency or to add comfort and visual interest.

End use The application or function for which a textile is designed or for which it is ultimately used.

Smart textiles or smart fabrics Sense and react to the environment or stimuli of an electrical, chemical, thermal, mechanical, magnetic, or other nature.

Technical or industrial textiles Include a broad range of materials that are widely used in special applications of a technical nature and that are generally not considered apparel or furnishings.

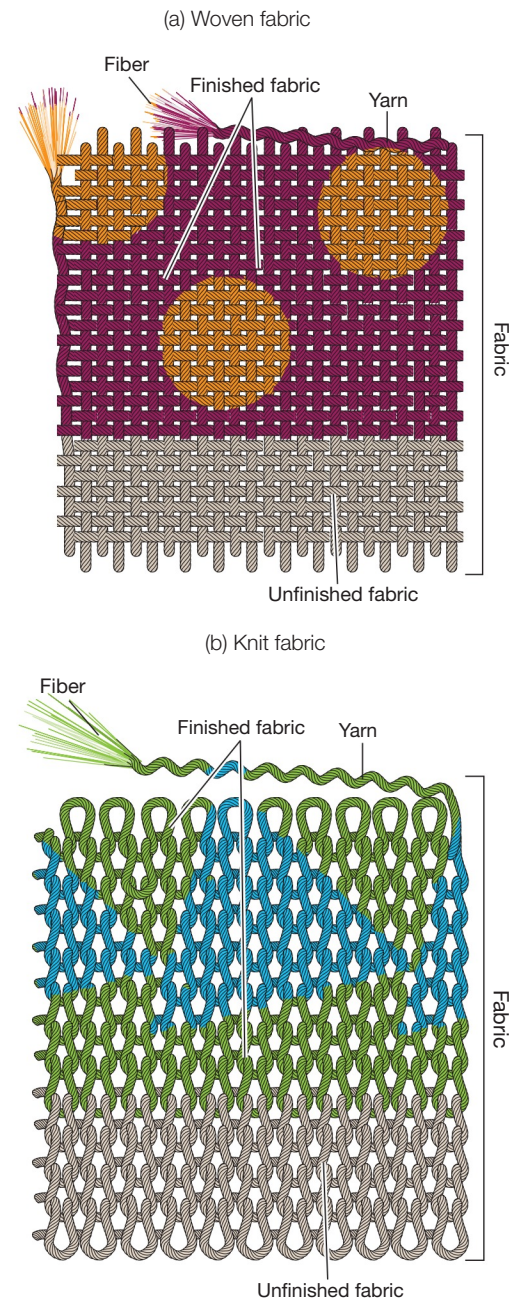


Figure 1.1 The components of a fabric: fiber, yarn, structure, and finish.

Most textiles are made of fibers that are processed into yarns and woven or knit into fabrics. Coloration and finishing add value, enhance appearance, or improve performance.



Figure 1.2 This technical textile reduces soil erosion on a slope.



Figure 1.3 Textiles used in the health care fields: self-adhering flexible wrapping, waterproof adhesive tape, elastic wrist support, waterproof cushioning tape, low trauma tape for pain-free removal, and flexible fabric bandages (clockwise from top left).

1 Learning Activity

Select Fabric #1 from your swatch kit. Dismantle it so that you have a fiber and a yarn. Describe the differences and similarities between these components. Compare what you have written with the definitions for fiber, yarn, and fabric stated above. Is the fabric finished in any way? State if you believe the fabric has been printed or dyed, and why? Determine an appropriate end use for the fabric.

Textiles and Quality of Life

From cradle to grave, we are surrounded by textiles. We encounter some textiles every day, such as **apparel** (clothing and accessories made from flexible materials), **interior textiles** also known as **interior furnishings** or **home fashions** (upholstered furniture, carpets and rugs, wall coverings, draperies and curtains, table linens, and towels and bed linens), and technical and industrial textiles (toothbrushes, bandages, and seat belts in cars). Other textiles are rarely viewed on a daily basis; however, they are omnipresent in our apparel (interlining and interfacing), interiors (nonwoven support materials and fiberfills used to enhance the comfort and appearance of upholstered furniture), and in technical and industrial textiles (insulation and moisture barriers).

No matter what element or walk of life, textiles are crucial for individual, community, and societal health and well-being. They provide protection and enhancement for sports and recreation; injuries are minimized with padded protective helmets, shoulder, and knee pads, and gloves specific to the sport; athletic performance is enhanced with carbon reinforcement fibers in golf clubs and tennis rackets. Textiles provide comfort and safety for animals and humans: farmers and ranchers protect crops and livestock with textile barrier fabrics; outdoor activities take place under tents and awnings to protect us from sun and rain. Life is prolonged and preserved by mending organs and tissues with sutures and textile structures; ballistic, fire, and slash-resistant vests protect police, firemen, and soldiers. Our homes and buildings provide protection to us through fiberglass insulation and polyethylene film wind and moisture barriers. Apparel ranges from soft and absorbent garments for newborn infants, to easy-care and colorful clothes for toddlers, to comfortable and stylish outfits for office workers, to rugged and durable gear for farmers and factory workers, to high fashion and elegant looks for weddings and celebrations. Many of these astonishing textiles were not possible before the development of manufactured fibers. It is challenging to envision what our lives would be like without them. Table 1.1 lists examples of technical and industrial textiles grouped by end-use category.

The newest innovations in smart and technical textiles have great potential for government agencies, the military, and consumers. For example, smart textiles are able to deliver medication in slow and controlled doses, monitor pulse and body temperature, promote safety with sensors that identify seat occupancy in vehicles, and keep wearers comfortable by promoting heat loss in warm weather and minimizing heat loss in cooler weather. In the future, some smart textiles are likely to have the ability to sense, receive, compute, and transmit information, such as weight, heartbeat, respiration, and even calories consumed. The possibilities of smart and technical textiles are boundless.

The field of textiles is ever-changing. Textiles are modified in response to changes in fashion, consumer demand, production costs and processes, government standards for safety and environmental quality, research developments, innovations in the industry, and

Table 1.1 Examples of Technical and Industrial Textiles Grouped by End-Use Category

Personal Hygiene	Transportation	Environment	Medical
Cotton balls	Bicycle helmets	Air and water filters	Arteries
Dental floss	Brake linings	Drainage screens	Bandages
Feminine hygiene	Convertible tops	Erosion barriers	Casts
Incontinence pads	Gaskets and seals	Oil-spill-control barriers	Dialysis filters
Loofahs	Interiors for planes, buses, cars, and trucks	Pond liners	Examination gowns
Makeup brushes	Road bed underlays	Sandbags	Gloves
Medicated pads	Seat belts and air bags	Seed blankets	Support wraps
Nail buffers	Tire cords	Shore protectors	Surgical masks
Tooth and hairbrushes		Snow and silt fences	Sutures
Wipes		Weed-control fabrics	Tissue engineering
			Vascular implants
Food	Animal Care	Agriculture	Protective Gear
Bags and sacks	Blankets	Anti-insect fabric	Abrasion-resistant gloves
Bakery filters	Leashes	Bags and sacks	Ballistic vests
Coffee filters	Livestock ground fabric	Bale coverings	Chemical-resistant gloves
Fast-food wrappers	Pet bed liners	Flexible tanks for storing liquids	Hazmat suits
Greenhouse light-reflective flooring	Poultry curtains	Hoses and belts	Heat/fire-resistant suits
Packaging materials	Restraints	Plant covers and tree wraps	Impact-resistant helmets
Tea bags	Saddles	Ropes	
	Stall liners	Tractor interiors	
Sports and Recreation	Manufacturing	Miscellaneous Products	Building Materials
Artificial playing surfaces	Belts	Artificial flowers/plants	Awnings
Backpacks	Conveyor belts	Banners and flags	Carpet and backing
Balls	Duct tape backing	Book bindings	Covers for wiring
Fishing line and nets	Gaskets and seals	Candle wicks	Drop cloths
Helmet liners	Hoses	Casket linings	Duct tape
Life jackets	Loading dock covers	Laptop bags and sleeves	Insulation
Protective pads	Mailing envelopes	Communication lines	Moisture barriers
Rafts and boat hulls	Noise reduction	Felt-tip pens	Paint rollers
Sails	Silk-screen mesh	Lampshades	Pool liners and covers
String for rackets	Tarpaulins	Mops and dusting cloths	Roofing materials
Tents		Scuba gear	Venetian blinds
Uniforms and specialty footwear			Wall coverings
			Window screens

Learning Activity 2

Go through the list of technical and industrial textiles in Table 1.1. Make a check mark by each of the textile products you used or likely encountered today. Compare your list with those of others in your class. What are some of the common and not-so-common items on the lists? Think about the last vacation that you took. Did you encounter any textiles on your trip not included in Table 1.1? What were they? What smart or technical textile do you have with you today? Imagine what the future will look like with smart and technical textiles. What are you most looking forward to?