Handbook Introduction

Students today generally have experience with materials and their properties through their use of toys, skateboards, bicycles, smart phones etc. Instructors can use this background to introduce Materials Science into their classrooms and thereby making the science and technology of everyday materials more real to their students. Materials Science principles adapt easily to hands-on activities related to real life materials and processes while enabling the instructor to use simple activities to teach basic science concepts.

More advanced materials understanding is needed by technologists and engineers as they work to consider that different materials act differently and have differing properties that depend on processing. The relationship of properties to structure and processing is basic to Materials Science. With newer materials having radically different properties than conventional metals, it is critical that users understand what to choose and why for their specific application. One cannot approach composites, plastics or ceramics as if they are just different-colored metals!

Materials Science instruction is also important due to the variety of new materials that are being developed and applied in a wide variety of products, including bulk, thin film and nano-structured systems. This is important since the ever-increasing sophistication of materials used in industry makes materials training essential for the workforce.

The hands-on activities and principles in this Handbook start simply then become more advanced as one proceeds through the Units, and provide a broad background in materials concepts and applications. They work equally well in secondary and college level classes and in workforce training and technician education, depending on the background and interests of the students.
The Handbook is not intended to be a comprehensive textbook, but rather provides flexibility in subject content to fit any training or educational situation. The many activities provide means to demonstrate scientific principles that can fit into any curriculum. The goal of this work is to provide means for programs to introduce the concepts of materials science education and training while providing quality instruction for further study in the subject.

Acknowledgments

We thank all of the authors whose work is presented in this Handbook and acknowledge the extent of experimentation and trials that have gone into each activity to make it interesting for students and useable to other instructors. Considerable work has also been done by the individual module reviewers and by the reviewers who focused on the various chapters to make sure that they flowed properly and provided instructors with quality curriculum. We thank all of our chapter coordinators and reviewers for the monumental tasks they undertook to make the Handbook a source for quality instruction. Appreciation is also extended to the MatEdU Center's National Advisory Board for their guidance. Major authors, chapter coordinators and reviewers, along with the members of the National Advisory Board are listed in Appendix B.

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Luke Ferguson, C12 Advanced Technologies LLC and Thomas Stoebe, University of Washington

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*Classroom activity*

1.1.2 Materials Science in Household Appliances  
Pacific Northwest National Laboratory  
*Classroom activity*

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Thomas Stoebe, U. of Washington  
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1.1.4 (Optional) Fracture Resistant Ceramics  
Thomas Stoebe, U. of Washington  
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L. Roy Bunnel, Southridge High School  
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Tanya David, et. al., Norfolk State University  
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Craig Johnson, Central Washington University  
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Carrie Kouadio, J. Muskin, U. of Illinois  
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Mary Reidmeyer, Missouri U. of Science and Technology  
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Thomas Stoebe, University of Washington and
Christopher Owen, Purdue University

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   Jean Frank, Thomas Nelson Community College

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Craig Johnson, Central Washington University
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Jean Frank, Thomas Nelson Community College
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Jean Frank, Thomas Nelson Community College
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 Kyle Bates-Green, Edmonds Community College

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Craig Johnson, Central Washington University

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Craig Johnson, Central Washington University

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Appendices

Appendix A: Correlations to Next Generation Science Standards* and A Framework for K-12 Science Education** for all Chapters and Modules in this Handbook

Appendix B: Principal Authors, Reviewers and Project Staff

Appendix C: Materials Science Core Competencies for Engineers and Technicians, referenced by competency category.

Appendix D: Author Index by Module
How to Use this Handbook

This work consists of independent educational Chapters and Units that begin at the introductory level and proceed into important applications areas. Each Unit consists of short, hands-on educational activities, called Modules in this Handbook. An instructor can choose to start at the beginning and proceed into each Unit as appropriate for his/her needs, or can focus on specific areas in different Chapters and Units. With flexibility and logical sequencing, the Handbook allows an instructor to start at the level of their students and proceed by choosing the best-fit activities for their class.

The Handbook provides proven instructional materials that can be utilized in a variety of settings. For K-12 classes, connections to the Next Generation Science Standards* are provided along with applicable connections to Science and Engineering Practice, Disciplinary Core Ideas and Crosscutting Concepts from A Framework for K-12 Science Education** These connections are provided in each Unit’s instructor’s guide and in a comprehensive listing in Appendix A. For workforce training and technician education, Core Competencies needed by technologists working with materials are included in the modules with an overall reference in Appendix C.

Because the Handbook is not intended to be a comprehensive textbook, it provides the instructor with wide latitude to introduce specific concepts and/or activities into existing courses. These activities and concepts have also been used successfully to develop introductory classes in Materials Science at the high school level, and more focused materials processing and manufacturing workshops for technology training.
How to Use this Handbook

Handbook Navigation

Development of the Handbook is focused on instructor usage, with each Chapter and Unit developing knowledge that advances in level as one proceeds from module to module. Instructors may start at any point, although some modules have recommended pre-requisites based on knowledge introduced earlier. For an instructor beginning to introduce materials concepts into a class or program, it is recommended that their program start with Chapter 1.

Handbook chapters, units and modules span a wide range of materials, processes and applications. Each Chapter is mounted as a separate file on the internet as follows:

- **Title page, Handbook Introduction, Table of Contents.**
- **How to Use this Handbook with How to Navigate this Handbook** and references.
- **Chapter 1, Introduction to Materials** provides introductory concepts and hands-on activities related to diverse parts of Materials Science. These lessons have been used successfully from K-12 to college as introductions to the subject. Generally, this Chapter should be presented first, and can be covered rapidly in more advanced classes.
- **Chapter 2, Metals and Alloys** provides an in-depth knowledge of metals and alloys based on properties, structure and processing. It concludes with an advanced look at the substitution of aluminum for steel in auto body construction.
- **Chapter 3, Composite Materials** focuses on the manufacture of composite materials, with separate sections appropriate for K-12 science and technology classes and for college-level/technology training programs. The Chapter looks at
How to Use this Handbook

materials used in engineering composites, manufacturing processes, and at the design of composite parts in larger systems along with testing and evaluation procedures.

- **Chapter 4, Polymers and Plastics** considers the properties and applications of polymers based on their structure, using hands-on classroom activities. Consideration is also given to biodegradable polymers and recycling.

- **Chapter 5, Ceramic Materials** investigates ceramic materials properties with activities and lessons related to mechanical behavior as well as optical and electronic applications used every day, with considerations of materials design for maximum performance.

- **Chapter 6, Engineering Materials and Design** applies engineering design principles to the selection and modification of materials properties, constraints based on materials performance, smart materials and sustainable design.

- **Appendix A:** Correlations to Next Generation Science Standards* and A Framework for K-12 Science Education** for all Chapters and Modules in this Handbook.

- **Appendix B:** Principle Authors, Reviewers, National Advisory Board and Project Staff.

- **Appendix C:** Core Competencies for Technicians Working with Materials.

- **Appendix D:** Author Index by Module.
Additional Curricula

Instructors wanting additional educational activities related to specific materials-related topics can find a variety of other, peer-reviewed modules, sortable by subject and author, at www.materialseducation.org/educators/matedu-modules. Further references are to be found in the lists of references provided in the Chapters and Modules.

A comprehensive list of further information may be found in the resources section of www.materialseducation.org, which includes relevant Materials Science-related references, including

- Websites and videos,
- Texts and other reference books,
- Workshop reports, and
- Published papers and publications.