Database Processing

Fundamentals, Design, and Implementation

FOURTEENTH EDITION

David M. Kroenke • David J. Auer

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14TH EDITION
Global Edition

David M. Kroenke

David J. Auer
Western Washington University

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Brief Contents

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Contents

Appendices

ONLINE APPENDICES: SEE PAGE 610 FOR INSTRUCTIONS

Appendix B: Getting Started with Systems Analysis and Design

Appendix C: E-R Diagrams and the IDEF1X Standard

Appendix D: E-R Diagrams and the UML Standard

Appendix K: Big Data

Preface

The 14th Global Edition of *Database Processing: Fundamentals, Design, and Implementation* refines the organization and content of this classic textbook to reflect a new teaching and professional workplace environment. Students and other readers of this book will benefit from new content and features in this edition.

New to This Edition

Content and features new to the 14th Global Edition of *Database Processing: Fundamentals, Design, and Implementation* include the following:

- The SQL topics in Chapter 2 have been reorganized and expanded to provide a more concise presentation of SQL queries. New material on SQL set operators (UNION, INTERSECTION, and EXCEPT) has been added to ensure that nearly all SQL query topics are covered in one chapter (the exception is correlated subqueries, which are still reserved for Chapter 8).
- The material on *Big Data* and the evolving *NoSQL movement* is summarized in Chapter 12 and then expanded upon in a new Appendix K–*Big Data*. This is an important topic that is constantly developing and changing, and the new appendix provides room for an extended discussion of the topic. Material on virtualization and cloud computing is updated in Chapter 12.
- Online chapters on Microsoft SQL Server 2014 (Chapter 10A), Oracle Database (Chapter 10B), and MySQL 5.6 (Chapter 10C) now have a section on importing data from Microsoft Excel 2013 worksheets.
- The book has been updated to reflect the use of Microsoft SQL Server 2014, the current version of Microsoft SQL Server. Although most of the topics covered are backward compatible with Microsoft SQL Server 2012 and Microsoft SQL Server 2008 R2 Express edition, all material in the book now uses SQL Server 2014 in conjunction with Office 2013 exclusively.
- Oracle's Oracle Database is now updated to Oracle Database 12*c*, and Oracle Database Express Edition 11*g* Release 2 (Oracle Database XE) is introduced as the preferred Oracle Database product for use on personal computers. The current version of the Oracle SQL Developer GUI tool provides a common interface to both versions of Oracle Database, and we provide detailed examples of how to use it.
- Microsoft Windows Server 2012 R2 is the server operating system and Windows 8.1 is the workstation operating system generally discussed and illustrated in the text. These are the current Microsoft server and workstation operating systems.
- We have updated online Appendix I–*Getting Started with Web Servers, PHP and the NetBeans IDE*. We are now using the NetBeans IDE instead of the Eclipse PDT IDE. This provides a better development environment with a much simpler set of product installations because the Java JDK and NetBeans are installed in one combined installation. This new material provides a simplified (but still detailed) introduction to the installation and use of the Microsoft IIS Web server, PHP, the Java JDK, and the NetBeans in Appendix I. All of these tools are then used for Web database application development as discussed in Chapter 11.

Fundamentals, Design, and Implementation

With today's technology, it is impossible to utilize a DBMS successfully without first learning fundamental concepts. After years of developing databases with business users, we have developed what we believe to be a set of essential database concepts. These are augmented by the concepts necessitated by the increasing use of the Internet, the World Wide Web, and commonly available analysis tools. Thus, the organization and topic selection of the 14th Global Edition are designed to:

- Present an early introduction to SQL queries.
- Use a "spiral approach" to database design.
- Use a consistent, generic Information Engineering (IE) Crow's Foot E-R diagram notation for data modeling and database design.
- Provide a detailed discussion of specific normal forms within a discussion of normalization that focuses on pragmatic normalization techniques.
- Use current DBMS technology: Microsoft Access 2013, Microsoft SQL Server 2014, Oracle Database 12*c* (and alternately Oracle Database Express Edition 11*g* Release 2), and MySQL 5.6.
- Create Web database applications based on widely used Web development technology.
- Provide an introduction to business intelligence (BI) systems.
- Discuss the dimensional database concepts used in database designs for data warehouses and online analytical processing (OLAP).
- Discuss the emerging and important topics of server virtualization, cloud computing, Big Data, and the NoSQL (Not only SQL) movement.

These changes have been made because it has become obvious that the basic structure of the earlier editions (up to and including the 9th edition–the 10th edition introduced many of the changes we used in the 11th, 12th, and 13th editions and retain in the 14th edition) was designed for a teaching environment that no longer exists. The structural changes to the book were made for several reasons:

- Unlike the early years of database processing, today's students have ready access to data modeling and DBMS products.
- Today's students are too impatient to start a class with lengthy conceptual discussions on data modeling and database design. They want to do something, see a result, and obtain feedback.
- In the current economy, students need to reassure themselves that they are learning marketable skills.

Early Introduction of SQL DML

Given these changes in the classroom environment, this book provides an early introduction to SQL data manipulation language (DML) SELECT statements. The discussion of SQL data definition language (DDL) and additional DML statements occurs in Chapters 7 and 8. By encountering SQL SELECT statements in Chapter 2, students learn early in the class how to query data and obtain results, seeing firsthand some of the ways that database technology will be useful to them.

The text assumes that students will work through the SQL statements and examples with a DBMS product. This is practical today because nearly every student has access to Microsoft Access. Therefore, Chapters 1 and 2 and Appendix A–*Getting Started with Microsoft Access 2013*, are written to support an early introduction of Microsoft Access 2013 and the use of Microsoft Access 2013 for SQL queries (Microsoft Access 2013 QBE query techniques are also covered).

If a non-Microsoft Access–based approach is desired, versions of Microsoft SQL Server 2014, Oracle Database, and MySQL 5.6 are readily available for use. Free versions of the three major DBMS products covered in this book (SQL Server 2014 Express Edition, Oracle Database Express Edition 11*g* Release 2 (Oracle Database XE), and MySQL 5.6 Community Edition) are available for download. Thus, students can actively use a DBMS product by the end of the first week of class.

BY THE WAY The presentation and discussion of SQL are spread over four chapters so students can learn about this important topic in small bites. SQL SELECT statements are taught in Chapter 2. SQL data definition language (DDL) and SQL data manipulation language (DML) statements are presented in Chapter 7. Correlated subqueries and EXISTS/NOT EXISTS statements are described in Chapter 8, while SQL transaction control language (TCL) and SQL data control language (DCL) are discussed in Chapter 9. Each topic appears in the context of accomplishing practical tasks. Correlated subqueries, for example, are used to verify functional dependency assumptions, a necessary task for database redesign.

This box illustrates another feature used in this book: BY THE WAY boxes are used to separate comments from the text discussion. Sometimes they present ancillary material; other times they reinforce important concepts.

A Spiral Approach to the Database Design Process

Today, databases arise from three sources: (1) from the need to integrate existing data from spreadsheets, data files, and database extracts; (2) from the need to develop new information systems projects; and (3) from the need to redesign an existing database to adapt to changing requirements. We believe that the fact that these three sources exist presents instructors with a significant pedagogical opportunity. Rather than teach database design just once from data models, why not teach database design three times, once for each of these sources? In practice, this idea has turned out to be even more successful than expected.

Database Design Iteration 1: Databases from Existing Data

Considering the design of databases from existing data, if someone were to email us a set of tables and say, "Create a database from them," how would we proceed? We would examine the tables in light of normalization criteria and then determine whether the new database was for a production system that allows new data to be inserted for each new transaction, or for a business intelligence (BI) data warehouse that allow users to only query data for use in reports and data analysis. Depending on the answer, we would normalize the data, pulling them apart (for the production transaction processing system), or denormalize the data, joining them together (for the BI system data warehouse). All of this is important for students to know and understand.

Therefore, the first iteration of database design gives instructors a rich opportunity to teach normalization, not as a set of theoretical concepts but rather as a useful toolkit for making design decisions for databases created from existing data. Additionally, the construction of databases from existing data is an increasingly common task that is often assigned to junior staff members. Learning how to apply normalization to the design of databases from existing data not only provides an interesting way of teaching normalization, it is also common and useful!

We prefer to teach and use a pragmatic approach to normalization and present this approach in Chapter 3. However, we are aware that many instructors like to teach normalization in the context of a step-by-step normal form presentation (1NF, 2NF, 3NF, then BCNF), and Chapter 3 now includes additional material to provide more support for this approach as well.

In today's workplace, large organizations are increasingly licensing standardized software from vendors such as SAP, Oracle, and Siebel. Such software already has a database design. But with every organization running the same software, many are learning that they can gain a competitive advantage only if they make better use of the data in those predesigned databases. Hence, students who know how to extract data and create read-only databases for reporting and data mining have obtained marketable skills in the world of ERP and other packaged software solutions.

Database Design Iteration 2: Data Modeling and Database Design

The second source of databases is from new systems development. Although not as common as in the past, many databases are still created from scratch. Thus, students still need to

learn data modeling, and they still need to learn how to transform data models into database designs that are then implemented in a DBMS product.

The IE Crow's Foot Model as a Design Standard

This edition uses a generic, standard IE Crow's Foot notation. Your students should have no trouble understanding the symbols and using the data modeling or database design tool of your choice.

IDEF1X (which was used as the preferred E-R diagram notation in the 9th edition of this text) is explained in Appendix C–*E-R Diagrams and the IDEF1X Standard*, in case your students will graduate into an environment where it is used or if you prefer to use it in your classes. UML is explained in Appendix D–*E-R Diagrams and the UML Standard*, in case you prefer to use UML in your classes.

BY THE WAY

The choice of a data modeling tool is somewhat problematic. Of the two most readily available tools, Microsoft Visio 2013 has been rewritten as a very rudimentary database design tool, while Oracle's MySQL Workbench is a database design tool, not a data modeling tool. MySQL Workbench cannot produce an N:M relationship as such (as a data model requires) but has to immediately break it into two 1:N relationships (as database design does). Therefore, the intersection table must be constructed and modeled. This confounds data modeling with database design in just the way that we are attempting to teach students to avoid.

To be fair to Microsoft Visio 2013, it is true that data models with N:M relationships can be drawn using the standard Microsoft Visio 2013 drawing tools. Unfortunately, Microsoft has chosen to remove many of the best database design tools that were in Microsoft Visio 2010, and Microsoft Visio 2013 lacks the tools that made it a favorite of Microsoft Access and Microsoft SQL Server users. For a full discussion of these tools, see Appendix E—*Getting Started with the MySQL Workbench Data Modeling Tools*, and Appendix F—*Getting Started with Microsoft Visio 2013*.

Good data modeling tools are available, but they tend to be more complex and expensive. Two examples are Visible Systems' Visible Analyst and CA Technologies' CA ERwin Data Modeler. Visible Analyst is available in a student edition (at a modest price), and a one-year time-limited CA Technologies' ERwin Data Modeler Community Edition suitable for class use can be downloaded from *http://erwin.com/products/data-modeler/community-edition*. CA Technologies has limited the number of objects that can be created by this edition to 25 entities per model and disabled some other features (see *http://erwin.com/content/products/CA-ERwin-r9-Community-Edition-Matrix-na.pdf*), but there is still enough functionality to make this product a possible choice for class use.

Database Design from E-R Data Models

As we discuss in Chapter 6, designing a database from data models consists of three tasks: representing entities and attributes with tables and columns; representing maximum cardinality by creating and placing foreign keys; and representing minimum cardinality via constraints, triggers, and application logic.

The first two tasks are straightforward. However, designs for minimum cardinality are more difficult. Required parents are easily enforced using NOT NULL foreign keys and referential integrity constraints. Required children are more problematic. In this book, however, we simplify the discussion of this topic by limiting the use of referential integrity actions and by supplementing those actions with design documentation. See the discussion around Figure 6-29.

Although the design for required children is complicated, it is important for students to learn. It also provides a reason for students to learn about triggers as well. In any case, the discussion of these topics is much simpler than it was in prior editions because of the use of the IE Crow's Foot model and ancillary design documentation.

Database Implementation from Database Designs

Of course, to complete the process, a database design must be implemented in a DBMS product. This is discussed in Chapter 7, where we introduce SQL DDL for creating tables and SQL DML for populating the tables with data.

BY THE WAY

David Kroenke is the creator of the semantic object model (SOM). The SOM is presented in Appendix H—*The Semantic Object Model*. The E-R data model is used everywhere else in the text.

Database Design Iteration 3: Database Redesign

Database redesign, the third iteration of database design, is both common and difficult. As stated in Chapter 8, information systems cause organizational change. New information systems give users new behaviors, and as users behave in new ways, they require changes in their information systems.

Database redesign is by nature complex. Depending on your students, you may wish to skip it, and you can do so without loss of continuity. Database redesign is presented after the discussion of SQL DDL and DML in Chapter 7 because it requires the use of advanced SQL. It also provides a practical reason to teach correlated subqueries and EXISTS/NOT EXISTS statements.

Active Use of a DBMS Product

We assume that students will actively use a DBMS product. The only real question becomes "which one?" Realistically, most of us have four alternatives to consider: Microsoft Access, Microsoft SQL Server, Oracle Database, and MySQL. You can use any of those products with this text, and tutorials for each of them are presented for Microsoft Access 2013 (Appendix A), SQL Server 2014 (Chapter 10A), Oracle Database 12*c* and Oracle Database Express Edition 11*g* Release 2 (Chapter 10B), and MySQL 5.6 (Chapter 10C). Given the limitations of class time, it is probably necessary to pick and use just one of these products. You can often devote a portion of a lecture to discussing the characteristics of each, but it is usually best to limit student work to one of them. The possible exception to this is starting the course with Microsoft Access and then switching to a more robust DBMS product later in the course.

Using Microsoft Access 2013

The primary advantage of Microsoft Access is accessibility. Most students already have a copy, and, if not, copies are easily obtained. Many students will have used Microsoft Access in their introductory or other classes. Appendix A–*Getting Started with Microsoft Access 2013* is a tutorial on Microsoft Access 2013 for students who have not used it but who wish to use it with this book.

However, Microsoft Access has several disadvantages. First, as explained in Chapter 1, Microsoft Access is a combination application generator and DBMS. Microsoft Access confuses students because it confounds database processing with application development. Also, Microsoft Access 2013 hides SQL behind its query processor and makes SQL appear as an afterthought rather than a foundation. Furthermore, as discussed in Chapter 2, Microsoft Access 2013 does not correctly process some of the basic SQL-92 standard statements in its default setup. Finally, Microsoft Access 2013 does not support triggers. You can simulate triggers by trapping Windows events, but that technique is nonstandard and does not effectively communicate the nature of trigger processing.

Using Microsoft SQL Server 2014, Oracle Database, or MySQL 5.6

Choosing which of these products to use depends on your local situation. Oracle Database 12*c*, a superb enterprise-class DBMS product, is difficult to install and administer. However, if you have local staff to support your students, it can be an excellent choice. Fortunately, Oracle Database Express Edition 11*g* Release 2, commonly referred to as Oracle Database XE, is easy to install, easy to use, and freely downloadable. If you want

your students to be able to install Oracle Database on their own computers, use Oracle Database XE. As shown in Chapter 10B, Oracle's SQL Developer GUI tool (or SQL*Plus if you are dedicated to this beloved command-line tool) is a handy tool for learning SQL, triggers, and stored procedures.

Microsoft SQL Server 2014, although probably not as robust as Oracle Database, is easy to install on Windows machines, and it provides the capabilities of an enterprise-class DBMS product. The standard database administrator tool is the Microsoft SQL Server Management Studio GUI tool. As shown in Chapter 10A, SQL Server 2014 can be used to learn SQL, triggers, and stored procedures.

MySQL 5.6, discussed in Chapter 10C, is an open source DBMS product that is receiving increased attention and market share. The capabilities of MySQL are continually being upgraded, and MySQL 5.6 supports stored procedures and triggers. MySQL also has excellent GUI tools in the MySQL Workbench and an excellent command-line tool (the MySQL Command Line Client). It is the easiest of the three products for students to install on their own computers. It also works with the Linux operating system and is popular as part of the AMP (Apache–MySQL–PHP) package (known as WAMP on Windows and LAMP on Linux).

BY THE WAY Because we only present currently available software products in this book, we cover MySQL 5.6 instead of MySQL 5.7. However, MySQL 5.7 is currently in release candidate status, which means that it will be generally available in the near future. All discussion of MySQL 5.6 in this book will also apply to MySQL 5.7.

BY THE WAY If the DBMS you use is not driven by local circumstances and you do have a choice, we recommend using Microsoft SQL Server 2014. It has all of the features of an enterprise-class DBMS product, and it is easy to install and use. Another option is to start with Microsoft Access 2013 if it is available and switch to SQL Server 2014 at Chapter 7. Chapters 1 and 2 and Appendix A are written specifically to support this approach. A variant is to use Microsoft Access 2013 as the development tool for forms and reports running against an SQL Server 2014 database.

If you prefer a different DBMS product, you can still start with Microsoft Access 2013 and switch later in the course. See the detailed discussion of the available DBMS products in Chapter 10 for a good review of your options.

Focus on Database Application Processing

In this edition, we clearly draw the line between *application development* per se and *database application processing*. Specifically, we have:

- Focused on specific database dependent applications:
  - Web-based, database-driven applications
  - XML-based data processing
  - Business intelligence (BI) systems applications
- Emphasized the use of commonly available, multiple-OS-compatible application development languages.
- Limited the use of specialized vendor-specific tools and programming languages as much as possible.

There is simply not enough room in this book to provide even a basic introduction to programming languages used for application development such as the Microsoft .NET languages and Java. Therefore, rather than attempting to introduce these languages, we leave them for other classes where they can be covered at an appropriate depth. Instead, we focus on

basic tools that are relatively straightforward to learn and immediately applicable to database-driven applications. We use PHP as our Web development language, and we use the readily available NetBeans integrated development environment (IDE) as our development tool. The result is a *very* focused final section of the book, where we deal specifically with the interface between databases and the applications that use them.

BY THE WAY Although we try to use widely available software as much as possible, there are, of course, exceptions where we must use vendor-specific tools. For BI applications, for example, we draw on Microsoft Excel's PivotTable capabilities and the Microsoft PowerPivot for Microsoft Excel 2013 add-in and on the Microsoft SQL Server 2012 R2 Data Mining Add-ins for Microsoft Office. However, either alternatives to these tools are available (OpenOffice.org DataPilot capabilities, the Palo OLAP Server) or the tools are generally available for download.

Business Intelligence Systems and Dimensional Databases

This edition maintains coverage of business intelligence (BI) systems (Chapter 12 and Appendix J). The chapter includes a discussion of dimensional databases, which are the underlying structure for data warehouses, data marts, and OLAP servers. It still covers data management for data warehouses and data marts and also describes reporting and data mining applications, including OLAP.

Appendix J includes in-depth coverage of two applications that should be particularly interesting to students. The first is RFM analysis, a reporting application frequently used by mail order and e-commerce companies. The complete RFM analysis is accomplished in Appendix J through the use of standard SQL statements. This chapter can be assigned at any point after Chapter 8 and could be used as a motivator to illustrate the practical applications of SQL midcourse. Finally, Appendix K provides additional material on Big Data and NoSQL databases to supplement and support Chapter 12.

Overview of the Chapters in the 14th Global Edition

Chapter 1 sets the stage by introducing database processing, describing basic components of database systems, and summarizing the history of database processing. If students are using Microsoft Access 2013 for the first time (or need a good review), they will also need to study Appendix A–*Getting Started with Microsoft Access 2013* at this point. Chapter 2 presents SQL SELECT statements. It also includes sections on how to submit SQL statements to Microsoft Access 2013, SQL Server 2014, Oracle Database, and MySQL 5.6.

The next four chapters, Chapters 3 through 6, present the first two iterations of database design. Chapter 3 presents the principles of normalization to Boyce-Codd normal form (BCNF). It describes the problems of multivalued dependencies and explains how to eliminate them. This foundation in normalization is applied in Chapter 4 to the design of databases from existing data.

Chapters 5 and 6 describe the design of new databases. Chapter 5 presents the E-R data model. Traditional E-R symbols are explained, but the majority of the chapter uses IE Crow's Foot notation. Chapter 5 provides a taxonomy of entity types, including strong, ID-dependent, weak but not ID-dependent, supertype/subtype, and recursive. The chapter concludes with a simple modeling example for a university database.

Chapter 6 describes the transformation of data models into database designs by converting entities and attributes to tables and columns, by representing maximum cardinality by creating and placing foreign keys, and by representing minimum cardinality via carefully designed DBMS constraints, triggers, and application code. The primary section of this chapter parallels the entity taxonomy in Chapter 5.

Chapter 7 presents SQL DDL, DML, and SQL/Persistent Stored Modules (SQL/PSM). SQL DDL is used to implement the design of an example introduced in Chapter 6. INSERT, UPDATE, MERGE, and DELETE statements are discussed, as are SQL views. Additionally, the principles of embedding SQL in program code are presented, SQL/PSM is discussed, and triggers and stored procedures are explained.

Database redesign, the third iteration of database design, is described in Chapter 8. This chapter presents SQL statements using correlated subqueries and the SQL EXIST and NOT EXISTS operators, and uses these statements in the redesign process. Reverse engineering is described, and basic redesign patterns are illustrated and discussed.

Chapters 9, 10, 10A, 10B, and 10C consider the management of multiuser organizational databases. Chapter 9 describes database administration tasks, including concurrency, security, and backup and recovery. Chapter 10 is a general introduction to the online Chapters 10A, 10B, and 10C, which describe SQL Server 2014, Oracle Database (both Oracle Database 12*c* and Oracle Database XE), and MySQL 5.6, respectively. These chapters show how to use these specific products to create database structures and process SQL statements. They also explain concurrency, security, and backup and recovery with each product. The discussion in Chapters 10A, 10B, and 10C parallels the order of discussion in Chapter 9 as much as possible, though rearrangements of some topics are made, as needed, to support the discussion of a specific DBMS product.

BY THE WAY

We have maintained or extended our coverage of Microsoft Access, Microsoft SQL Server, Oracle Database, and MySQL (introduced in *Database Processing: Fundamentals, Design, and Implementation,* 11th edition) in this book. In order to keep the bound book to a reasonable length and to keep the cost of the book down, we have chosen to provide some material by download from our Web site at *www.pearsonglobaleditions.com/kroenke*. There you will find:

- Chapter 10A—*Managing Databases with Microsoft SQL Server 2014*
- Chapter 10B—*Managing Databases with Oracle Database*
- Chapter 10C—*Managing Databases with MySQL 5.6*
- Appendix A—*Getting Started with Microsoft Access 2013*
- Appendix B—*Getting Started with Systems Analysis and Design*
- Appendix C—*E-R Diagrams and the IDEF1X Standard*
- Appendix D—*E-R Diagrams and the UML Standard*
- Appendix E—*Getting Started with MySQL Workbench Data Modeling Tools*
- Appendix F—*Getting Started with Microsoft Visio 2013*
- Appendix G—*Data Structures for Database Processing*
- Appendix H—*The Semantic Object Model*
- Appendix I—*Getting Started with Web Servers, PHP, and the NetBeans IDE*
- Appendix J—*Business Intelligence Systems*
- Appendix K—*Big Data*

Chapters 11 and 12 address standards for accessing databases. Chapter 11 presents ODBC, OLE DB, ADO.NET, ASP.NET, JDBC, and JavaServer Pages (JSP). It then introduces PHP (and the NetBeans IDE) and illustrates the use of PHP for the publication of databases via Web pages. This is followed by a description of the integration of XML and database technology. The chapter begins with a primer on XML and then shows how to use the FOR XML SQL statement in SQL Server.

Chapter 12 concludes the text with a discussion of BI systems, dimensional data models, data warehouses, data marts, server virtualization, cloud computing, Big Data, structured storage, and the Not only SQL movement.

Supplements

This text is accompanied by a wide variety of supplements. Please visit the text's Web site at *www.pearsonglobaleditions.com/kroenke* to access the instructor and student supplements described below. Please contact your Pearson sales representative for more details. All supplements were written by David Auer, Scott Vandenberg, Bob Yoder, and Darren Lim.

For Students

Many of the sample databases used in this text are available online in Microsoft Access, Microsoft SQL Server 2014, Oracle Database, and MySQL 5.6 formats.

For Instructors

At the Instructor Resource Center, *www.pearsonglobaleditions.com/Kroenke*, instructors can access a variety of print, digital, and presentation resources available with this text in downloadable format. Registration is simple and gives instructors immediate access to new titles and new editions. As a registered faculty member, you can download resource files and receive immediate access to and instructions for installing course management content on your campus server. In case you ever need assistance, our dedicated technical support team is ready to help with the media supplements that accompany this text. Visit *http://247.pearsoned.com* for answers to frequently asked questions and toll-free user support phone numbers.

The following supplements are available for download to adopting instructors:

- Instructor's Resource Manual
- Test Bank
- TestGen® Computerized Test Bank
- PowerPoint Presentations

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Larry Booth, *Clayton State University*
Jason Deane, *Virginia Polytechnic Institute and State University*
Barry Flachsbart, *Missouri University of Science and Technology*

Andy Green, *Kennesaw State University*
Dianne Hall, *Auburn University*
Jeff Hassett, *University of Utah*
Barbara Hewitt, *Texas A&M, Kingsville*
William Hochstettler, *Franklin University*
Margaret Hvatum, *St. Louis Community College*
Nitin Kale, *University of Southern California, Los Angeles*
Darrel Karbginsky, *Chemeketa Community College*
Johnny Li, *South University*
Lin Lin, *New Jersey Institute of Technology*
Mike Morris, *Southeastern Oklahoma State University*
Jane Perschbach, *Texas A&M University–Central Texas*
Catherine Ricardo, *Iona College*
Kevin Roberts, *DeVry University*
Ioulia Rytikova, *George Mason University*
Christelle Scharff, *Pace University*
Julian M. Scher, *New Jersey Institute of Technology*
Namchul Shin, *Pace University*
K. David Smith, *Cameron University*
M. Jane Stafford, *Columbia College-Jefferson City*
Marcia Williams, *Bellevue Community College*
Timothy Woodcock, *Texas A&M University-Central Texas*

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David Kroenke
Seattle, Washington

David Auer
Bellingham, Washington

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Contributors

Ketil Danielsen, *Molde University College*
Mathy Paesen, *ACE-GROEP T*
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Reviewers

Cindy Baker, *American University of Sharja*
Neerja Sethi, *Nanyang Technological University*
Franck Laurence, *Conservatoire National des Arts et Métier*