Table of Contents

Preface

Researchers and educational software developers have talked about building authoring tools for intelligent tutoring systems (ITSs), adaptive and knowledge-based instructional systems, and other forms of advanced-technology learning environments (ATLEs) ever since these forms of educational software were introduced in the 1970s. The technical complexity and high development costs of these systems contrasts sharply with the common picture of education as a "home grown" activity performed by individual teachers and trainers who craft lessons tailored for each situation. There have been two primary reasons to create authoring tools for ATLEs: to reduce development cost, and to allow practicing educators to become more involved in their creation. The goal of creating usable authoring tools dovetails with the recent trend toward interoperability and reusability among these systems.

We use the phrase "advanced-technology learning environment" to refer to educational software on the leading edge of practice and research. These systems go beyond traditional computer-based instruction or educational simulations by providing one or more of the following benefits:

- Providing rich, or even "immersive" interfaces so that students can "learn by doing" in realistic and meaningful contexts.
- Dynamically adapting the interface or content to the student's goals, skill level, or learning style.
- Providing expert hints, explanations, or problem solving guidance.
- Allowing "mixed-initiative" tutorial interactions, where students can ask questions and have more control over their learning.
- Incorporating instructional models that base interactions on proven educational theories, or that allow the interactions to more closely approach the benefits of individualized instruction by a competent pedagogue.

The ATLE authoring tools field has advanced significantly since the first conference workshop on the subject in 1995. Since then there have been a number of international workshops dealing with the subject (including workshops at the AI in Education international conferences in 1995, 1997, 1999; the Intelligent Tutoring Systems international conference in1996; and the American Association of Artificial Intelligence Fall Symposium in 1997). In addition there have been several special issues of research journals on this topic (including the International Journal of AI in Education Vol. 8. No. 3, 1998, and Vol. 10 No. 1, 1999; J. of the Learning Sciences Vol. 7 No. 1 1998; and J. of Instructional Science Vol. 26 Nos. 3-4 1998). This volume, which is the first book on the subject, contains chapters providing updated reports on all of these workshops and publications. It provides a comprehensive picture of the state of the art in ATLE authoring systems, with representative chapters from almost every major researcher in the field. Contributions to this volume come from an international cadre of researchers from

Canada, the Netherlands, Spain, the United Kingdom, and the United States. Significant work in authoring tools is ongoing in several other countries as well (including Japan and Germany).

This volume should appeal to many readers interested in the use and/or development of ATLEs. To quote from the overview chapter by Murray:

> I imagine two types of readers. First are academic or industry personnel in the field of instructional software research or development. They might ask the question "what methods and designs have been used, and how successful have they been?" in their efforts to build the next generation of systems. The second type of reader is the user, developer, or purchaser of instructional software (advanced, intelligent, or otherwise) who might ask the question: "what is really available, or soon to be available, to make ITS authoring cost effective?"

The reader will note the word "toward" in the title of the volume. The field is still very much in a formative stage. The systems described in the 17 chapters to follow are predominantly R&D efforts or local success stories. That is, few have been used to produce numerous tutoring systems nor have they been used by people not closely associated with a research team (with some notable exceptions, as discussed in the Overview chapter). This state of affairs with ATLE authoring tools reflects the state of ATLEs in general, which have shown some successes but have been slow to enter the main-stream commercial education and training markets. However, despite its formative nature, the importance of making ATLEs more cost effective and authorable warrants the publication of a book such as this that describes the state of the art. The design issues are complex and the implemented solutions are quite diverse. Much progress has been made in articulating the issues and fleshing out solutions, and a number of projects have completed empirical studies demonstrating usability and cost-effectiveness. A few of the chapters describe projects that were completed some years ago, and these were included because their research results and design innovations still represent the state of the art on certain issues.

The chapters in this volume are organized based on an analysis of authoring systems given in the Overview chapter which distinguishes authoring tools according to the following categories: Authoring Tutors for Device and Process Simulations, Authoring Tutors that Encode Human Expertise, Authoring Tutors that Include Instructional Strategies, and Special Purpose Authoring Tools. Some readers may wish to read the final Chapter first, an overview of ITS authoring tools, and authoring tools issues.

Chapter 1 describes SimQuest, an authoring tool for creating simulation-based learning environments that focus on science concepts and principles. Chapter 2 describes XAIDA, an authoring tool that has been used to develop simple simulations that can address a variety of knowledge types, including facts, concepts, procedures, and principles. Chapter 3 describes RIDES, a tool for authoring tutorials bases on sophisticated device simulations. Chapter 4 describes Demonstr8, a prototype authoring tool that explores authoring domain content by having authors providing examples and demonstrations, and then intelligently creating

generalizations based on these example cases. Chapter 5 describes DIAG, a system for authoring tutors in electronic fault diagnosis that significantly simplifies the process of defining and providing instruction for complex devices and the numerous fault conditions that can occur in these devices. Chapter 6 describes DNA, a knowledge elicitation tool that simulates a semi-structured interview process for eliciting factual, conceptual, and procedural domain knowledge for an ITS. Chapter 7 describes Instructional Simulator, one of a set of commercially available authoring tools that simplify authoring for simple device simulations and conceptual knowledge. Chapter 8 describes REDEEM, an authoring tool that converts traditional computer-based instructional content into an intelligent tutor by allowing teachers to specify multiple teaching strategies, each of which is defined for a particular type of student. Chapters 9 and 10 describe the IRIS authoring tool and CREAM-tools. These systems incorporate different methods for building ITSs that incorporate complex instructional design principles that utilize the instructional theories of Gagne, Bloom, and Merrill. Chapter 11 described the Eon system, which includes highly interactive authoring tools, for authoring subject matter, tutoring strategies, interfaces, and student models. Chapter 12 describes IDLE-tools, which are used to create "investigate and decide goal-based learning environments." Chapter 13 gives an overview of authoring tools for adaptive hypermedia systems, with a more detailed description of the InterBook. Chapter 14 describes LAT, an authoring tool for creating tutors that use conversational grammars to simulate product sales representative phone conversations with customers. Chapter 15 presents contains a general design "meta-model" for ITS authoring tools (this material in this chapter was part of the originally published paper on the Eon system, Chapter 11, but was separated into a different paper and extended for this volume). Chapter 16 contains a general discussion on interoperability and component-based architectures for authoring tools, and includes examples from tools used to author model tracing tutors. Chapter 17 is an overview of the state of the art in ITS authoring, including an analysis and comparison of 31 authoring tools.

Related workshops and symposia

- ED-MEDIA-94 conference: "Teaching Strategies and Intelligent Tutoring Systems." Vancouver Canada, July, 1994. Organizing Committee: N. Major, T. Murray, K. VanMarcke.
- AI&ED-95 conference: "Authoring Shells for Intelligent Tutoring Systems, " August, 1995, Washington, D.C. Organizing Committee: N. Major, T. Murray, C. Bloom.
- ITS-96 conference workshop: "Architectures and Methods for Designing Cost-Effective and Reusable ITSs," June 1996, Montreal, Canada. Organizing committee: B. Cheikes, D. Suthers, T. Murray, N. Jacobstein.
- AAAI Fall-97 Symposium "Intelligent Tutoring System Authoring Tools," Cambridge, MA, Nov. 1997. (C. Redfield, B. Bell, H. Halff, A. Munro, T. Murray, (Organizing Committee)

- AI-ED-97 conference, "Issues in Achieving Cost-Effective and Reusable Intelligent Learning Environments," August, 1997, Kobe, Japan. Organizing Committee: D. Suthers, C. Bloom, M. Dobson, T. Murray, A. M. Paiva.
- AI-ED-99 workshop, Ontologies for Intelligent Educational Systems," LeMans France. Chairs: Riichiro Mizoguchi & Tom Murray

Journal Special Issues

- International Journal of Artificial Intelligence in Education, Special Issues on Authoring Systems for Intelligent Tutoring Systems, Vol. 8. No. 3-4, 1997; and Vol. 10 No. 1, 1999, guest editors Tom Murray and Stephen Blessing.
- Journal of the Learning Sciences, Special Issue on authoring tools for interactive learning environments, Vol. 7 No. 1 1998, guest editors Benjamin Bell and Carol Redfield.

Contributors

Shaaron Ainsworth
ESRC Centre for Research in Development, Instruction & Training, School of Psychology, University of Nottingham, Nottingham, NG7 2RD, UK. sea@psychology.nottingham.ac.uk

Ainhoa Álvarez
Department of Computer Languages and Systems, Computer Science Faculty, University of the Basque Country UPV/EHU, 649 Postakutxa, 20080 Donostia, Spain. jipalara@si.ehu.es

Ana Arruarte
Department of Computer Languages and Systems, Computer Science Faculty, University of the Basque Country UPV/EHU, 649 Postakutxa, 20080 Donostia, Spain. arruarte@si.ehu.es

Benjamin Bell
Principal Cognitive Engineer, CHI Systems, Inc. , CHI Systems, Inc., 1035 Virginia Drive, Suite 300, Fort Washington, PA 19034. BBell@chisystems.com

Stephen B. Blessing
Carnegie Learning, Inc., 1200 Penn Avenue, Suite 150, Pittsburgh, PA, 15222. blessing@carnegielearning.com

Rick Blumenthal
Regis University, 3333 Regis Blvd., L-12, Denver, CO 80221; 303-458-4304, rblument@regis.edu, www.regis.edu.

Peter Brusilovsky
School of Information Sciences, Pittsburgh PA 15260, USA. peterb@mail.sis.pitt.edu

Isabel Fernández-Castro
Department of Computer Languages and Systems, Computer Science Faculty, University of the Basque Country UPV/EHU, 649 Postakutxa, 20080 Donostia, Spain. isabelfc@si.ehu.es

Tom Chudanov
I/T Lead Systems Analyst, USAA Information Technology, 9800 Fredericksburg Road, San Antonio, Texas 78288,; 210-913-8992, tom.chudanov@usaa.com.

Mary Dirnberger
PSC 482 Box 2547 , FPO AP 96362; dirnberg@konnect.net.

Scott Dooley
Knowledge Analysis Technologies, 4940 Pearl East Circle, Suite 200, Boulder, CO 80301; 303-545-9092, dooley@k-a-t.com, www.k-a-t.com.

Begoña Ferrero
Department of Computer Languages and Systems, Computer Science Faculty, University of the Basque Country UPV/EHU, 649 Postakutxa, 20080 Donostia, Spain. jipfemab@si.ehu.es

Claude Frasson
Département d'informatique et de recherche opérationnelle, Université de Montréal, Case postale 6128, succursale Centre-ville, Montréal (Québec), H3C 3J7, Canada. frasson@iro.umontreal.ca

Gilles Gauthier
Département d'informatique, Université du Québec à Montréal, Case postale 8888, succursale Centre-ville, Montréal (Québec), H3C 3P8, Canada. gauthier.gilles@uqam.ca

Elizabeth G. Gibson
SBC Online Strategy and Integration, 9505 Arboretum Blvd. - 7th Floor, Austin, TX 78759-6337; 512-372-5785; Fax: 512-241-5785, elizabeth.gibson.1@sbc.com.

Jim Greer
Department of Computer Science, University of Saskatchewan, Saskatoon, Canada S7N 5A9. greer@cs.usask.ca

Shirley Grimshaw
ESRC Centre for Research in Development, Instruction & Training, School of Psychology, University of Nottingham, Nottingham, NG7 2RD, UK.

Henry M. Halff
Halff Resources, 9 Villa Verde, San Antonio, TX 78230-2709; 210-493-7501; Fax: 760-495-6395, henry@halffresources.com, http://www.halffresources.com.

Mary Hayes
Faculty of Education, Ada Byron King Building, The Nottingham Trent University, Clifton Campus Clifton Lane, Nottingham NG11 8NS UK. Mary.Hayes@ntu.ac.uk

Patricia Yee Hsieh
System Human Resources Office, The Texas A&M University System, John B. Connally Bldg., 5th floor, 301 Tarrow, College Station, TX 77840-7896; 979-458-6166; Fax: 979-845-5281, phsieh@tamu.edu http://sago.tamu.edu/shro/pagetraining.htm.

Ton de Jong
Faculty of Behavioral Sciences, University of Twente, P.O. box 217, 7500 AE Enschede, The Netherlands. A.J.M.deJong@edte.utwente.nl

Wouter van Joolingen
Graduate School of Teaching and Learning, University of Amsterdam, Wibautstraat 2-4, 1091 GM Amsterdam, The Netherlands. wouter@ilo.uva.nl

Nigel Major
ESRC Centre for Research in Development, Instruction & Training, School of Psychology, University of Nottingham, Nottingham, NG7 2RD, UK.

Lori Meiskey
CreekPath Systems, 7420 E. Dry Creek Parkway, #100, Longmont, CO 80503; lmeiskey@creekpath.com, www.creekpath.com.

Alan Munro
University of Southern California, Behavioral Technology Lab, 250 No. Harbor Drive, Suite, 309, Redondo Beach, CA 90277. munro@usc.edu

Tom Murray
Hampshire College School of Cognitive Science, Amherst, MA, USA. tmurray@hampshire.edu, http://helios.hampshire.edu/~tjmCCS/

Roger Nkambou
Département d'informatique, Université du Québec à Montréal, Case postale 8888, succursale Centre-ville, Montréal (Québec), H3C 3P8, Canada. nkambou.roger@uqam.ca

Carol Luckhardt Redfield
St. Mary's University, Computer Science Department, 1 Camino Santa Maria, San Antonio, Texas 78228-8524; 210-346-3298, credfield@stmarytx.edu.

Steven Ritter
Carnegie Learning, Inc., 1200 Penn Avenue, Suite 150, Pittsburgh, PA 15222. steve@carnegielearning.com

Valerie J. Shute
Principal Research Scientist, Educational Testing Service, Rosedale Rd., MS-01R, Princeton, NJ 08541 USA. vshute@ets.org

Randall Sparks
Knowledge Analysis Technologies, 4940 Pearl East Circle, Suite 200, Boulder, CO 80301,;303-545-9092, rsparks@k-a-t.com, www.k-a-t.com.

Lisa A. Torreano
Product Development Manager, Bright Brains, Inc. , 2121 Sage Rd., Suite 385, Houston, TX 77056 USA. ltorreano@brightbrains.com

Douglas M. Towne
Behavioral Technology Laboratories, University of Southern California, 1120 Pope St., Suite 201C, St. Helena, CA 94574 USA. dtowne@usc.edu

Jean Underwood
Division of Psychology, Nottingham Trent University, Burton Street, Nottingham, NG1 4BU, UK. Jean.Underwood@ntu.ac.uk

Maite Urretavizcaya,
Department of Computer Languages and Systems, Computer Science Faculty, University of the Basque Country UPV/EHU, 649 Postakutxa, 20080 Donostia, Spain. maite@si.ehu.es

Brenda M Wenzel
Senior Engineering Psychologist, TRADOC Analysis Center, ATRC-WSMR-WGA,Systems Training, White Sands Missile Range, NM 88002-5502, 505-678-4661 (phone); 505-678-6887 (FAX). wenzelbm@trac.wsmr.army.mil.

Leslie Wheeler
Carnegie Learning, Inc., 1200 Penn Avenue, Suite 150, Pittsburgh, PA 15222. leslie@carnegielearning.com

Ben Williams
ESRC Centre for Research in Development, Instruction & Training, School of Psychology, University of Nottingham, Nottingham, NG7 2RD, UK.

David Wood
ESRC Centre for Research in Development, Instruction & Training, School of Psychology, University of Nottingham, Nottingham, NG7 2RD, UK. djw@psychology.nottingham.ac.uk

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Chapters 2, 3, 4, 5, 8, 14, 17.

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The following chapters contain updated versions of papers that originally appeared in the Journal of the Learning Sciences, Special Issue on Authoring Tools for Interactive Learning Environments, Vol. 7 No. 1 1998, guest editors Benjamin Bell and Carol Redfield:

Chapters 11, 12, 15, 16.

An earlier version of Chapter 9 appeared in the International Journal of Computers in Education, 1997, Vol. 8(3/4), 341-381.