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Educational Authoring Tools and the Educational Object Economy: Introduction to this Special Issue from the East/West Group

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Abstract:

This special issue brings together perspectives from universities and publishers working on new media learning technologies. We begin by describing the way these organizations came to work together, before introducing the articles in this special issue. We then proceed to highlight the important issues that are emerging from their individual and collective efforts within the Group, and most recently from the author-reviewer debate in this issue. We now invite you to build on these discussions with your own contributions.

Commentaries:

All JIME articles are published with links to a commentaries area, which includes part of the article's original review debate. Readers are invited to make use of this resource, and to add their own commentaries. The authors, reviewers, and anyone else who has 'subscribed' to this article via the website will receive email copies of your postings.

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1. Historical Overview

In the Spring of 1993, the East/West Authoring Tools Group began its collaboration in response to a request for proposals from the Defense Advanced Research Projects Agency's Technology Reinvestment Project (DARPA's TRP). DARPA's TRP was a dual use program aimed at lowering post-Cold War defense spending by stimulating industry to create products of use to both the private sector and the defense community. One promising area for dual use products was authoring tools that could help lower the cost of producing computer-based instructional material. DARPA solicited proposals for collaborative research projects aimed at creating easy to use, interoperable, platform independent authoring tools and instructional materials. An important aspect of the project was to accelerate the commercialization of authoring tools by fostering a joint industry (technology and publishing companies) and academic collaboration. The East/West Group combined the efforts of organizations from the east of the U.S. (Houghton Mifflin Company, PWS Publishers (an International Thomson company), University of Massachusetts at Amherst, Carnegie Mellon University) with the west (University of Colorado at Boulder, Stanford University, and Apple Computer).

At that time, the two publishers had successfully integrated new media materials into their traditional paper-based product lines. For example, Houghton Mifflin Company has successful on-line reference products (dictionary, thesaurus, spell checkers), and PWS has successful engineering software packages that accompany higher education textbooks. However, expanding the range of new media titles would require innovation on many fronts, especially empowering more authors to produce titles in the new media. Because the university collaborators had each successfully developed new authoring tools and next generation instructional systems and applied their technologies in domains of interest to the publishers (mathematics, engineering, medicine) that were also good candidates for dual use, the stage was set for an important next step: moving from academic research to pre-commercial proofs-of-concept with active industry participation. The university authoring tools and learning environments had been developed in Macintosh-based Lisp and SuperCard, but for a number of reasons, including lack of cross-platform interoperability, these efforts faced commercialization challenges.

Also at that time, Apple and IBM had joined forces to create Kaleida, a joint venture corporation that had begun work on an "author once, run anywhere" multimedia environment known as ScriptX. CD-ROMs had just begun their rise as a standard storage media for multimedia content, and ScriptX was proposed as an object-oriented, cross-platform, media-rich standard for interactive CD-ROM content. Apple led the proposal submission process, because Apple's Advanced Technology Group already had been collaborating with the universities and had been creating an authoring tool development technology called SK8, built on Macintosh-based Lisp with plans for ScriptX output. In the summer of 1993, Apple submitted

the East/West proposal to the National Science Foundation (NSF), which was the organization DARPA had chosen to administer their authoring tools program.

2. Phase I: Authoring Tools for CD-ROMS

In December of 1993, the East/West group's proposal was selected by DARPA and NSF to receive an award. The stage was set for a mutually beneficial collaboration: the universities had pioneered the creation of authoring tools for next generation learning environments demonstrating diverse pedagogical approaches, the technology industry was selling CD-ROM equipped computers in record-breaking numbers, two key industry players had joined forces to create a cross-platform multimedia standard with powerful tool building technology on the horizon, and the publishers were eager to expand their new media offerings and lower production costs to mitigate the risk of expanding their businesses into the information age. The gist of the original proposal was to use SK8 technology to rebuild the university authoring tools, and output ScriptX CD-ROM titles that the publishers could commercialize. The key research issue was to understand how to create better task-specific authoring tools so that courseware authors could choose the right tool for the job and dramatically decrease authoring times and thus lower production costs.

By March of 1996, many things had changed. First, the Internet and the World Wide Web were already beginning to challenge the notion that CD-ROMs would be the dominant means of distributing educational software in the first few years of the 21st century. Second, it was proving difficult to produce multimedia titles using Kaleida's ScriptX that had reasonable performance on commonly available educational computing platforms, which at that time had an order of magnitude less memory and processing power than standard machines today. Furthermore, Sun's Java was being rapidly adopted by the programming community as a "write once, run anywhere" standard for the Web, and spreading as fast as the Web itself. In addition, Apple Advanced Technology Groups' SK8 authoring tool building technology which had selected ScriptX as its target runtime environment was running into all the challenges of making the transition from complex research prototype to streamlined commercializable product in a corporation facing tremendous new business challenges of its own.

3. Lessons Learned

It was a time for taking stock of the situation, and creating a new plan. Two things were clear: Java had raced past ScriptX as the object-oriented, cross-platform runtime of choice, and the Internet would ultimately replace CD-ROMs as the preferred means of distributing educational software. In addition, three important and unexpected lessons had been learned about authoring tools based on our collective experience creating and using our tools in many contexts. All three lessons dealt with social aspects of authoring and software development.

The first lesson can be summarized as follows: *"No matter how easy to use one makes an authoring tool through clever applications of cognitive science and technology, only a small fraction of the people with good ideas about instructional software and capable of learning to use the tools will in fact build things. The majority of people will instead make suggestions and try to influence what the builders are building."* We learned this lesson especially through experience with Cocoa, an authoring tool that allows kids to build simulated worlds and publish them on the WWW. Six months after introducing Cocoa to a classroom of students who all learned to use the tool, a handful of self-selected Cocoa world builders became the ones who would implement their own ideas as well as the ideas of other students. This appeared to have more to do with the desire for certain types of social interaction between the students than merely a division of labor, though no formal studies of the phenomenon have been undertaken.

The second lesson can be summarized as follows: *"Often the people most capable of doing a job such as improving a piece of educational software are prevented from doing the job by social convention, intellectual property protection barriers, or business model restrictions."* We learned this lesson after unsuccessfully seeking budget to port an authoring tool to several platforms. The ports would have required hiring people and training them to do the job at a cost of several hundred thousand dollars and taking several months to accomplish. Instead, the source code was made available on the Web, and within just a few weeks, self-selected experts motivated by access to the freely available source code did the job at no cost. Without releasing the sources under an "intellectual capital appreciation" license that gave the most capable people in the world the right and an incentive to do the job, the work would have taken longer, cost more, or simply not been done at all. Linux, Apache, and Solaris software are all benefiting from similar open source communities (OSC), and Netscape's Communicator is about to adopt a similar model.

The third lesson is just common sense in hindsight, and can be summarized as follows: *"What is the first question an authoring tool user should ask before using a tool to create a piece of educational software? Answer: Does the software or something like it already exist, and, if so, who created it and will they allow it to be reused?"* Being part of a large collective effort, it was an all too common experience to gather for a quarterly meeting and see that two people had independently developed nearly identical components. Overcoming the problem of unnecessary duplicated effort is not simply an authoring tool issue, but an authoring community issue. Members of the authoring community must be able to search the collective work of the group to efficiently find what they want before building it.

4. Phase II: Authoring Communities for the Internet

In December of 1996, the East/West Authoring Tools Group embarked on the second phase of the joint research project. The second phase would focus on leveraging the Internet and the emerging Java standard for cross-platform interoperability to move beyond simply creating authoring tools, and attempt to create an expanded authoring community based on finer grained educational objects. To be successful, the authoring community approach would need to address some of the lessons learned from the first phase of the project, such as: allowing people other than the authoring tool users to participate in the process of creating educational software, motivating self-selected experts to reuse and add value to the work of others, and providing a means to locate existing software before building from scratch.

A fundamental part of the second phase involved making existing authoring tools create Java output and moving them closer to commercialization. For example, Agentsheets, Inc., which is a commercial spin-off from the University of Colorado at Boulder, created an authoring tool called Ristretto that produces Java-based simulations. With Ristretto, authors create simulations that can be embedded in Web pages and used with Java-enabled browsers.

In phase two of the project, the role of the publishers also changed. During phase one, the publishers were primarily focused on using authoring tools to lower production costs of new media titles. In phase two, the publishers have provided perspectives on the challenges faced by educators trying to adopt new media materials, as well as perspectives on the challenges of setting up new media business models.

In June of 1997, Apple with assistance from the entire East/West Group launched the Educational Object Economy (EOE) website ¹ which has become the largest directory of educational Java applets on the Web. Part of the metadata that can be associated with educational objects in the EOE directory are reviews and comments from anyone in the community, thereby allowing educators and others to make suggestions about ways they would like to see the educational objects improved. Because source code is freely available for about 25% of the educational objects, authors have invited others to build on and improve their work. In addition, using the search capabilities at the EOE site, authors can see if relevant material is available before building an educational object from scratch. While the site is steadily growing in content and members, it has not yet reached critical mass. Educators have provided suggestions for improving only a small fraction of applets in the EOE directory, and only a few of the objects in the EOE have actually been reused or combined with other applets. Nevertheless, as the number of educational Java applets grows and a better understanding of the incentives that motivate members to take an active role in the community emerge, the EOE may yet reach critical mass. One modest measure of success is the growing number of organi-

¹ *Educational Object Economy, The EOE Foundation* <<http://www.eoe.org>>

zations leveraging the EOE in their own work, as well as those setting up their own versions of the EOE.

5. Overview of the Articles

The articles in this special issue can be divided into three groups: those that focus on specific authoring tools and authoring for specific purposes, those that focus on interoperability and reuse of software components in the broader context of authoring communities and lifelong learning, and those that focus on the challenges and opportunities faced by publishers working with university faculty to bring new media instructional products to market. Readers of this special issue can trace the path from research idea to commercial product, and gain an appreciation for the many opportunities and challenges along the way. Authoring tool technology not only helps lower the cost of producing educational software, but it can also be used to engage learners in constructivist activities and engage educators in customizing content to meet their own instructional needs. However, as the amount of educational software created by users of authoring tools increases, the question arises as to how the materials can be combined and reused in new ways (both technically and legally). Furthermore, the question arises as to how materials can be effectively brought to market, overcoming barriers to adoption and navigating the challenges of the digital information age. Here, we briefly comment on the specific articles that make up this special issue.

Three articles offer the reader an in depth look at specific authoring tools, as well as some of the purposes for which authoring tools are constructed.

- *Authoring Content in the PAT Algebra Tutor*
by Steven Ritter, John Anderson, Michael Cytrynowicz and Olga Medvedeva
- *Shop Class for the Next Millennium: Education through Computer-Enriched Handicrafts*
by Michael Eisenberg and Ann Nishioka Eisenberg
- *Learn to Communicate and Communicate to Learn*
by Alexander Repenning, Andri Ioannidou and James Ambach

The article by Ritter, *et al.*, presents an authoring tool called pSAT for problem sets used by the PAT Algebra Tutor, which is a type of intelligent tutoring system. Educators can use the authoring tool to create new algebra word problems for students. The authoring tool is domain specific, but the design principles uncovered and discussed in the article have broad applicability. Furthermore, the task of ensuring that the tool provides adequate feedback to users so that they are able to determine that the system will correctly present the content under a wide range of user strategies, preferences and abilities is no small matter.

The article by Eisenberg and Eisenberg presents a delightful authoring tool called HyperGami, which is an educational CAD system for the creation of paper polyhedral models and sculptures. HyperGami is a tool that supports “educational craft” activities. The authors prefer the notion of a future that emphasizes the real, tangible works of hands and minds, over the purely virtual world of so many educational software systems.

The article by Repenning, *et al.* presents Agentsheets, which can be viewed as a tool that empowers individuals to quickly and easily create educational simulations. More importantly, Agentsheets can be viewed as part of a communication medium that can help cultivate a sense of educational community among its users. How is this done? Rather than focus on the tool metaphor alone, which can isolate individuals, they focus on constructivist activities within a more social context supported by a shared communication medium. This article provides an excellent transition into the next group of articles because it envisions a world of many small computational objects that are being actively shared and exchanged between learners who are “learning to communicate and communicating to learn.”

Three articles focus on interoperability and reuse of software components in the broader context of authoring communities and lifelong learning.

- *Scaleable Integration of Educational Software: Exploring The Promise of Component Architectures*
by Jeremy Roschelle, Jim Kaput, Walter Stroup and Ted Kahn
- *A Model for Distributed Curriculum on the World Wide Web*
by Tom Murray
- *Learning Technologies in Support of Self-Directed Learning*
by Gerhard Fischer and Eric Scharff

Roschelle, *et al.* provide an excellent introduction to the promise of software components as a way to overcome the current problem of fragmentary collections of educational software “islands” that are difficult or impossible to combine. Why would anyone want to combine pieces of educational software? For example, the author of an ecosystem simulation might want to make use of a particular piece of graphics software to show population fluctuations rather than develop yet another grapher. Promoting reuse can lead to lower development costs and higher quality educational software products. An integration architecture developed by the authors allows for separately produced tools to be combined in the same window, dynamic linking across multiple representations, and drag and drop authoring without traditional programming.

The bulk of Murray's research with the East/West Consortium concerned authoring tools (Murray, 1998b). Murray's article in this issue focuses on a matter of growing importance for the Web's evolution, namely, interoperability between different Web resources. Murray describes a framework called the Model for Distributed Curriculum (MDC), that uses a topic server architecture to allow one Web-based tutorial to include a specification for another tutorial. Key to MDC is the challenge of organizing Web-based curricula into a "topic space," and building on metadata standards to describe pedagogically relevant properties of Web-based tutorials. Murray's discussion of how one might negotiate the human and technical challenges which face such a project are relevant to many initiatives proposing the adoption of metadata or ontologies as the basis for knowledge-based internet search.

Fischer and Scharff argue that domain-oriented design environments can serve as models for emerging economies of educational knowledge. Domain-oriented design environments allow learners to engage and solve their own problems, by providing contextualized support, and by exploiting breakdowns as opportunities for learning. The authors argue that the creation and evolution of communities that share educational software might be best understood as a problem in self-directed learning, similar in fact to the problem learners experience as they use domain-oriented design environments.

Two articles from publishers describe opportunities and challenges for new media adoption.

- *Publishing New Media in Higher Education: Overcoming the Adoption Hurdle*
by Leslie Bondaryk
- *Educational Publishing and the World Wide Web*
by Ann Marion and Elizabeth Hacking

Bondaryk's article first describes the three prerequisites to new media adoption by faculty: awareness of benefits, willingness to try, and ability to use effectively. Next, Bondaryk proposes several methods that can be effective for disseminating new media products into the marketplace, focusing primarily on methods such as workshops that educate and support faculty.

Marion and Hacking argue that print and new media will co-exist for quite some time because of the relative merits of both media types. However, they see critical needs as well as key opportunities for emerging technologies in the educational software arena. While better solutions are needed for handling rights, royalties, and intellectual property protection, technologies like metadata for query enhancements and work flow tools for customer support are providing a foundation for improved new media business models.

From authoring tools stimulating new media content development to authoring communities struggling to share interoperable components, and finally to new business opportunities and challenges, this special issue touches on a wide range of topics. We hope this issue will stimulate more conversations between the diverse communities—educators, researchers, software developers, and businesses—who must work together to create an information age economy of new media educational resources.

6. Key Issues

In this section, we highlight the key issues that have emerged from the author-reviewer discussions. Readers are invited to follow the references to the review discussions linked to the articles, which remain open for further commentary.²

6.1 Task-Specific versus General Purpose Authoring Tools

Several of the projects described in this special issue explore this distinction. The basic question posed is which is ‘better’: general purpose authoring tools that have wide applicability or more task-specific tools that are tailored to particular curricular or domain needs?

Steve Ritter and Greg Kearsley debate these issues in the context of the PAT Algebra Tutor. One outcome of this issue may be the conclusion that successful systems embody both general purpose and task-specific elements, as demonstrated in the PAT tutor, Agentsheets, and HyperGami.

Another outcome of the diverse projects represented in this issue is the realisation that this notion of ‘better’ is too simplistic -- the suitability of general purpose or task-specific tools really depends on situation-specific goals; i.e., for use ‘by whom’ and ‘for what purposes’. Following on, related issues are what constitutes authoring and who will do it?

6.2 What Constitutes Authoring?

In the PAT Tutor project, the focus is on content authoring and a special problem situation authoring tool was constructed according to five design principles. Several reviewers felt this article would benefit by including a comparison with commercial multimedia authoring tools (see discussion starting here).

² *There are many links from this section into the special issue articles and review debates. The reader can follow these directly from the Web version of this editorial*
<<http://www-jime.open.ac.uk/98/10>>

Roschelle *et al.* take a different approach and view authoring as a large-scale composition task where communicating software components are composed into a larger curricular structure. They use mechanisms such as drag'n drop into containers to support the composition of components. In the review debate, Royston Sellman and Alex Repenning note that rarely do components match your needs 100% and approaches such as end-user programming and scripting are also required to tailor components to local needs. Both Agentsheets and HyperGami take this programmability approach and view authoring as an end-user programming activity.

6.3 Who Will Do It?

Many of the articles in the special issue explore different conceptions concerning who will engage in authoring activities. Using Agentsheets, learners are authors and construct their own simulations. In the HyperGami project, both teachers and learners participate in the authoring process. In the PAT and Component Architecture projects, the focus is on supporting teachers as authors. In the review debates, participants point out both the benefits (see Henry Lieberman's comment) and the challenges of teachers as authors (see Chris DiGiano on making models visible, and Jeremy Roschelle on teachers' reluctance to engage in scripting, but willingness to use drag and drop).

Two articles by professional publishers explore broader definitions of educational community, and include editors and publishers as authoring participants. While these articles describe new models of publishing, many reviewers felt that details about the new roles of editors and publishers were missing (see Andy Reilly's concerns in Bondaryk about what constitutes editing and Jane Moran's concerns in Marion and Hacking about changing roles in publishing).

6.4 From Authoring Tools to Authoring Communities

Analogous to technological shifts in computing platform from standalone to networked computers, the projects changed from focusing on making isolated authoring tools usable by individuals to supporting authoring communities. The types of support explored has taken many forms, including support for sharing of application pieces, the sharing of entire applications, and supporting collaborative construction activities.

Agentsheets and its Behaviour Exchange support communities of learners and teachers to engage in all three of these activities. Reviewers Mary Beth Rosson and Josie Taylor considered the applications described in the article to be inspired and impressive examples how end-user programming and program sharing can enable new uses of technology for educational purposes. However, both reviewers have difficulties with the authors' theoretical stance on the contrasting

metaphors of “computer as tool” versus “computer as medium”, and their “media cube” framework provoked extensive discussion. Taylor suggests the authors explore a Vygotskian perspective of inter/intrasubjectivity. Rosson suggests there are parallels with recent work on activity theory. Rosson also suggests connecting the discussion of sharing to related work on code reuse.

This is the approach taken by Fischer and Scharff. They describe the need for self-directed learning environments and argue that supporting software reuse in educational communities is essential for the long-term viability of such environments. They put forward a framework for analyzing educational object repositories based on the cognitive processes of location, comprehension, and modification.

In a different vein, the HyperGami project is blending computational media with physical paper crafts. The authors argue that physical artifacts help serve as visible reminders of one’s place in a social network and there is an interesting debate on issues surrounding product longevity and social currency. Agnes Kulkuska-Hulme argues that there are large personal differences in the value of artifacts as social currency. Timothy Koschmann points out that the authors may have missed one of the key benefits of their approach -- the ability of artifacts to sustain a community of practice.

Murray’s article looks into the future and discusses the technical infrastructure necessary to support the large-scale distribution of educational resources over the internet. Franz Schmalhofer points out the significant human factors facing an ontology-based initiative, such as coping with different perspectives and priorities within the user community.

6.5 Multiple Media, Complementarity, and Barriers to Adoption

Articles by the publishers Bondaryk, and Marion and Hacking, look at authoring as a broader activity resulting in a mix of related materials. Interesting debates concerning the design and adoption of multiple media materials arise in several contexts.

Bondaryk argues that complementary texts play a crucial role in facilitating adoption of new media by teachers in higher education. Reilly questions why this is so, asking is it simply familiarity or are there pedagogic reasons for the appeal of texts? Bondaryk also argues that adoption is hindered by fear of obsolescence. Both Reilly and Anderson point out that this is also a design issue - some media are designed to replace the teacher and others to complement the teacher. Roy Rada agreed with the author that faculty development activities such as workshops were crucial for overcoming adoption barriers.

Murray's article considers the possibilities of large scale interoperability between online educational resources, recognising the considerable adoption barriers that remain between "the promise and the pragmatics" of such an initiative. A fundamental challenge is to devise processes by which communities can evolve ontologies and definitions.

On a similar theme, David Redmiles highlights that Roschelle et al.'s vision of large-scale component reuse and sharing depends also on the adoption of standards for component interoperability. Sellman's comment on the rapid pace of technical change (suggesting that the authors' discussion of web media needs to be brought up to date) is also a reminder of the moving target facing component reuse and interoperability.

6.6 New Business Models

One of the goals of the East/West Group was to move good research ideas closer to commercialisation. A recurring theme across many articles is the lack of existing business models for either: (1) making money with educational software (e.g., see Roschelle's response to a reviewer) or (2) sharing educational resources in an economically viable way. These difficulties are further exacerbated by upheavals in the publishing business.

For instance, many articles cite Apple's Educational Object Economy as an example of support for authoring communities. But Henry Lieberman claims this is a misnomer since the system has no economic model or provision for charging. Ann Marion agrees it lacks a complete business model. However, a key goal of the research is to stimulate exploration into new business models, and there is a growing number of resources at the EOE Web site that describe alternative business models.

Marion and Hacking examine the upheaval the World Wide Web has had on the educational publishing business. They put forward a new business model being tried at Houghton Mifflin called the 'digital value circle.' Moran notes that while this model is theoretically interesting, the authors present insufficient practical evidence to support it. Jane Moran and another reviewer discuss the value added by publishers and the 'disintermediation' effect of the Web as it severs the traditional link between distribution and production services. These debates continue when discussing market readiness and the new business role of publishers later in the article.

6.7 How to Judge Success?

One of the difficulties of this line of research is how to judge success? There are issues surrounding what to judge -- the learning efficacy of a particular resource, the usability of authoring tools, or the scale of sales and adoption of a particular product. Many reviewers felt most of the articles needed further work in these analyses areas.

Reviewers felt that two of the systems-oriented articles (i.e., the PAT tutor and the distributed curriculum approach) needed more examples to illustrate how users would interact with the technology. In response to reviewers requests for empirical evidence of Agentsheets' utility, Repenning *et al.* added several school case studies in support of their claim that it is educationally beneficial, surely the yardstick by which we must measure work.

A contentious claim was the idea that success or quality can be judged by sales. Andy Reilly, Leslie Bondaryk and Roy Rada debate this issue when considering the approach taken by Bondaryk.

What emerges from the articles and the debate is a feeling for the complexity of the undertaking. As ideas and resources move out of research labs and into realistic use situations, a host of factors can affect their ultimate success (and most are out of the researcher's control as found by Soloway, cited by Rosson). Another compounding factor is that most the projects in this special issue require or promote practices that are radically different from current norms. In these cases, judging success is a long-term prospect since requisite new practices do not arise over night but instead are learned or evolved gradually over time.

Nobody doubts the challenges to the innovation, adoption and evaluation of educational authoring tools, or the dissemination and reuse of 'educational objects', be they software components or tutorials. The work of the East/West Group presented and debated in this special issue documents a concerted effort to make several steps down this road. We leave it to the reader to judge these contributions, and hope that you are provoked to engage with the authors and reviewers to further advance the work presented. As Ann Marion asks, the real issue is how do we invent the future?

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