Jl. of Interactive Learning Research (1999) 10(2), 195-215

"Thick" Authenticity: New Media and Authentic Learning

DAVID WILLIAMSON SHAFFER
Harvard University
8 Story Street
Cambridge, MA 02138, USA
dws@media.mit.edu
http://www.media.mit.edu/~dws

MITCHEL RESNICK
MIT Media Laboratory
mres@media.mit.edu
http://www.media.mit.edu/~mres

The term "authentic" has become something of a buzzword in recent years when applied to educational interventions. It is applied loosely and inconsistently to a wide range of theoretical and practical work. This paper argues that the concept of authenticity should be analyzed more closely. An analysis of the literature on authentic education suggests that there are four identifiable "kinds" of authentic learning: (a) learning that is personally meaningful for the learner, (b) learning that relates to the real-world outside of school, (c) learning that provides an opportunity to think in the modes of a particular discipline, and (d) learning where the means of assessment reflect the learning process. Each of these kinds of authenticity, on its own, has contradictions and problems associated with it. The paper argues for a "thick" view of authenticity, which recognizes that the different "kinds" of authenticity presented in the literature are interdependent and mutually-supporting: we can not really achieve one without the other. The paper then analyzes how, because of their ability to support different aspects of authentic learning simultaneously, computational media are particularly well-suited to support thickly authentic learning. The idea of thick authenticity thus provides a potentially useful guide for educators trying to design computational learning environments.

In recent years, there has been an explosion in the number of articles in the education literature on the subject of "authentic" education. In the Educational Resources Information Center (ERIC) catalog, for example, the number of English-language articles on authenticity rises from 40 to 50 articles per year in the early 1980s to well over 250 articles in 1994. But despite (or perhaps because of) all of this scholarly discussion of authenticity, there is little consensus as to what the term really means. Articles about "authentic"[1] education provide their own definition of the term (see, e.g., Engel, 1994). Definitions conflict, leading at times, to pointed debate among various advocates of authenticity (see, Cizek, 1991).

In this paper we suggest that new media provide both an opportunity and an incentive to look more closely at the concept of authenticity. Our goal is not to present a comprehensive discussion of theories of authenticity, or of new media and learning, or even of the relationship of new media to authentic learning. Rather, our objective is to provide a framework for thinking about these issues, and hopefully a way to move beyond stereotypical views of new media and authentic learning. In order to do this, we describe a conceptual structure for thinking about "authenticity" in education; we then use that structure to look at the role of new media in learning.

This paper begins with an analysis of authentic education as represented in the general literature on education, including a typology of different "kinds" of authenticity described in various articles. We then look at how computational media can help create these different kinds of "authentic" learning environments. We argue, ultimately, for a "thick" view of authenticity, which recognizes that the different "kinds" of authenticity presented in the literature are interdependent and mutually-supporting: we can not really achieve one without the other. This suggests that because of their ability to support different aspects of authentic learning simultaneously, new media are particularly well-suited to support thickly authentic learning.

FOUR KINDS OF AUTHENTICITY

This paper began in a research seminar in the spring of 1996. We were discussing a series of articles on new media and authentic learning when it became clear that the term "authentic" learning was problematic. In particular, we realized that different authors were using the term in different ways: there seemed to be different "kinds" of authenticity that were perhaps related, but that were used to argue for different interventions, different kinds of tools, and ultimately for different educational goals.

n the number of articles in
tic" education. In the Edu-
alog, for example, the num-
ises from 40 to 50 articles
les in 1994. But despite (or
on of authenticity, there is
is. Articles about "authen-
the term (see, e.g., Engel,
inted debate among various

ovide both an opportunity
ncept of authenticity. Our
n of theories of authentici-
elationship of new media to
vide a framework for think-
move beyond stereotypical
der to do this, we describe a
city" in education; we then
in learning.
ntic education as represent-
ing a typology of different
cles. We then look at how
ferent kinds of "authentic"
a "thick" view of authentici-
of authenticity presented in
pporting: we can not really
it because of their ability to
simultaneously, new media
hentic learning.

TICITY

he spring of 1996. We were
d authentic learning when it
was problematic. In particu-
the term in different ways:
city that were perhaps relat-
rventions, different kinds of
als.

To get a sense of the conceptual space of "authentic learning," we conducted a meta-analysis of the literature on authenticity. In August 1996, we searched for the terms "authentic" and "authenticity" in the ERIC catalog, producing a list of 2011 citations. From these 2011 citations, we examined a random sample of 100 articles and categorized each article based on the way it used "authenticity." There were four broad uses of "authentic learning"[2] (see Figure 1) and in each category, we examined additional articles from the ERIC catalog to form a more complete picture of the positions represented in the original sample.

One immediate result of this inquiry was the observation that each of these broad positions on authenticity described an *alignment* between some aspect of pedagogy and some other important aspect of the educational experience (see also Engel, 1994). Different theoretical positions about authenticity can thus be characterized by looking at the various things that are aligned with practice in authentic learning. As shown in Figure 1, authentic learning can mean: (a) materials and activities aligned with the world outside the class room, (b) assessment aligned with (what students really should learn from) instruction, (c) topics of study aligned with what learners want to know, and/or (d) methods of inquiry aligned with the essential practices of a discipline. In this first section of the paper, we discuss each of these alignments (which we refer to as real-world authenticity, authentic assessment, personal authenticity, and disciplinary authenticity)—as well as their pedagogical consequences.

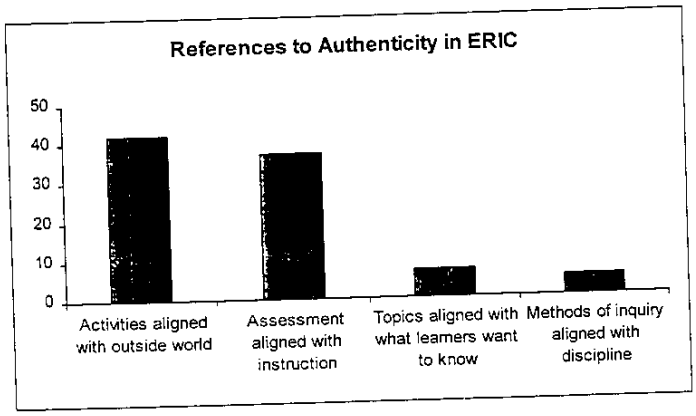

Figure 1. The four types of "authentic education"

Materials and Activities Aligned With the Outside

In real-world authenticity, the materials and activities of the learning environment reflect or recreate some aspect of the world outside of school (or outside of the learning environment more generally). The idea is that people should learn by doing the same kinds of things that they will do in "real life" outside of the environment in which learning takes place. So, for example, authentic activities might ask students to investigate a "real" problem such as thorium waste in nuclear power or Legionnaires disease (Stepien & Gallagher, 1993). Real-world authentic activities might use period music to create a sense of atmosphere for students as they study history (Lello, 1980), use comic books to help students learn a foreign language (Williams, 1995), or have students create a newspaper to learn writing skills (Denman, 1995). In general, real-world authentic activity includes anything that works "toward production of discourse, products, and performances that have value or meaning beyond success in school" (Newmann & Wehlage, 1993, p. 8).

Assessment Aligned With What Students Really (Should) Learn From Instruction

Authentic assessment has been the subject of heated and sometimes divergent discussion in recent years, but one of the common threads that runs through articles on authenticity in assessment is that assessment should be more connected to learning. In particular, advocates of authentic assessment argue that the things students do when being assessed (assessment tasks) should be more like the things students do while learning (learning tasks; see, e.g., Shepard, 1989). There are several key theoretical points that support this position. Theorists argue that since assessment drives instruction (the familiar idea that teachers "teach to the test"), we should ask students to perform in assessments in the ways we want them to learn (Engel, 1994; Shepard, 1989; Wiggins, 1989a). Advocates of authentic assessment argue that one way to insure this alignment of learning and evaluating is to make assessment part of the learning process itself—that is, to structure assessment so that students actually learn something while taking the test. These ideas are contrasted with "traditional" assessment, which is (theorists argue) characterized by decontextualised questions and multiple choice answers designed to sort students rather than help them learn (Engel, 1994; Shepard, 1989). Instead, "authentic" assessment suggests alternatives that come under a variety of names: performance, portfolio, and exhibition. (For a comprehensive overview see Baron & Wolf, 1996.)

ivities of the learning en-
orld outside of school (or
). The idea is that people
hey will do in "real life"
place. So, for example,
e a "real" problem such
lisease (Stepien & Gal-
ise period music to cre-
history (Lello, 1980),
uage (Williams, 1995),
skills (Denman, 1995).
thing that works "to-
ances that have value
ehlage, 1993, p. 8).

l) Learn From

d and sometimes di-
on threads that runs
sessment should be
uthentic assessment
(assessment tasks)
ng (learning tasks;
al points that sup-
drives instruction
ıould ask students
arn (Engel, 1994;
assessment argue
uating is to make
structure assess-
g the test. These
(theorists argue)
choice answers
, 1994; Shepard,
at come under a
ı comprehensive

Topics Aligned With What Learners Want to Know

Proponents of personal authenticity argue that students play a critical role in determining whether an activity is worthwhile—and some theorists claim that whether learners find an activity engaging and personally meaningful is the *only* important measure of its authenticity. Myers (Myers, 1993), for example, claims that "an activity, no matter how exciting, can be authentic only after [students] own it personally," and that "authentic" means something that *students* think of as "real or genuine." Thus activities that have personal authenticity should challenge and empower students to exceed personal limits, as well as make a demonstrable difference in students' lives. Examples of such activities include Lego/Logo activities where students seek to answer questions that arise for them as they encounter personally meaningful problems (Lafer & Markert, 1994), or activities where students help define content and engage "in work they can honor" (Perrone, 1994). Personal authenticity, in other words, argues that the educational significance of an activity must be judged—at least in part—by its significance to the learner.

Questions and Methods Aligned With the Essential Practices of a Discipline

The traditional academic disciplines such as mathematics, history, science, and language arts have been at the core of scholarly research and discourse for hundreds of years. As such, they are a part of the intellectual foundation and heritage of Western culture. Proponents of disciplinary authenticity argue that "learning to think" means learning to think using the tools and methods of these established intellectual traditions. Thus, students should learn history by "making history" for themselves like professional historians (Kobrin, Abbott, Elinwood, & Horton, 1993), or tackle "engaging and interesting questions" of mathematics in the same ways that mathematicians do (D'Ambrosio, 1995). In some ways, this sounds like real-world authenticity: students learning about things that are real to professionals—in this case, professional scholars. The difference is that disciplinary authenticity assumes the existence of coherent, academic disciplines with rules of inquiry, and further assumes that students should learn to use these tools for thinking in the way academicians use them. Students should not only be solving problems, but that they should be doing so in ways that build on the prior knowledge and intellectual tradition of particular disciplines (see Newmann, 1991).

Problems With the "Kinds" of Authenticity

Each of the kinds of authenticity described above has problems or issues associated with it. Some of these problems are practical issues of implementation. But more revealing, each of the positions—when looked at in isolation—has underlying theoretical problems and inconsistencies.

Some proponents of real-world authenticity, for example, take an oversimplified or even cartoonish view of the real world in designing learning activities. One author describes, for example, a classroom circus where students juggle while calling out numbers, or count the number of elephants circling the room (Sprague, 1993). While it is true that a circus is an event from the "real world" outside the class room, the activities described hardly seem like they belong under the big top. Interventions such as this take elements of the real world, but then distort them to present traditional content in a new window-dressing. On a more philosophical level, the mere act of taking parts of the real world and placing them within the classroom frame changes their context and thus their meaning. Some theorists argue that the very act of excerpting real children's literature for basal readers, for example, distorts the original stories (Reutzel & Larsen, 1995).

Authentic assessment has similar practical and theoretical problems. The idea of authentic assessment has been co-opted and applied to traditional tests of student achievement, resulting in oddities such as "authentic" science assessments where the teacher conducts a demonstration and then asks students to explain what happened (Radford, Ramsey, & Deese, 1995). The Michigan Education Assessment Program describes as "authentic" a multiple choice test to evaluate students' "attitudes and self-perceptions," "knowledge about reading," and ability to construct meaning from texts, reporting the results on a normalized scale (Roeber & Dutcher, 1989). A more fundamental problem is that forms of assessment that are authentic in one domain may not translate as effectively to other domains as proponents claim. For example, "portfolios"—a means of assessment used in the arts world—can become merely collections of old homework papers when used in other subjects. In general, it is not clear that one can apply the *forms* of authentic assessment without also respecting the *substance* of what is being assessed (see Cossentino & Shaffer, in press). It may not be possible to talk about authentic assessment without also looking at the authenticity of what is being learned.

Psychologists and philosophers such as Kohut and Heidegger describe the idea of an "authentic self," which suggests the idea of personal authenticity has a solid theoretical grounding (Chessick, 1988). At the same time,

there are a number of competing definitions of the authentic self in the literature on psychology and philosophy, including: (a) the ability to exist outside of supporting social institutions and conventions; (b) the ability to feel secure without external protection; (c) the ability to be integrated and cohesive in the aspects of ones personality; (d) the ability to remain independent within relationships; (e) the ability to act in accord with one's own impulses and values; and (f) the ability to be self-reflective (Chessick, 1988; Fenn, 1992; Havens, 1986; Heuscher, 1987). At the very least, more work needs to be done explaining how each, any, or all of these meanings of authentic existence translates into the learning domain. In practical terms, students are individuals with distinct likes and interests. It may be difficult to construct a coherent curriculum that every student will regard as personally meaningful.

Finally, despite the long history of academic disciplines, there is not a consensus as to what are and are not the essentials of the various traditional fields of study. There are, for example, debates within the mathematics community about what is worth teaching and why, and arguments about the role of proof in mathematical thinking and whether or not students should learn formal proofs (Davis & Hersh, 1982; Simon, 1994). Similarly, Martin et al (Martin, Kass, & Brouwer, 1990) argue that there is no single "authentic science," but rather a collection of perspectives for thinking about and evaluating scientific inquiry, including methodological, epistemological, falsificationist, personal, private, public, objectivist, historical, social, and technological. Saying students should learn "real" mathematics or "real" science is not a reliable way to determine what should and should not be studied.

Towards a More Comprehensive Picture of Authenticity

The idea that authenticity is an important aspect of successful learning experiences is certainly not new. Dewey wrote of the need to act "in behalf of purposes that are intrinsically worthwhile" (Dewey, 1938), and as early as 1866, William Ware of the Massachusetts Institute of Technology was writing about the value of having students work on practical projects drawn from genuine problems in the field of study (Ware, 1866). In more recent years, the literature of education research and practice (as represented by the ERIC database) has seen an increasing number of articles that refer to authentic educational experiences. Interestingly, up until 1988, most of the articles about authentic learning referred to language learning, particularly to the use of authentic materials in foreign language learning. However, after the publication of Archbald and Newmann's *Beyond Standardized Testing*

in 1988 (Archbald & Newmann, 1988) and articles by Wiggins in 1989 (Wiggins, 1989a; Wiggins, 1989b), the number of references to authentic education rose dramatically (see Figure 2).

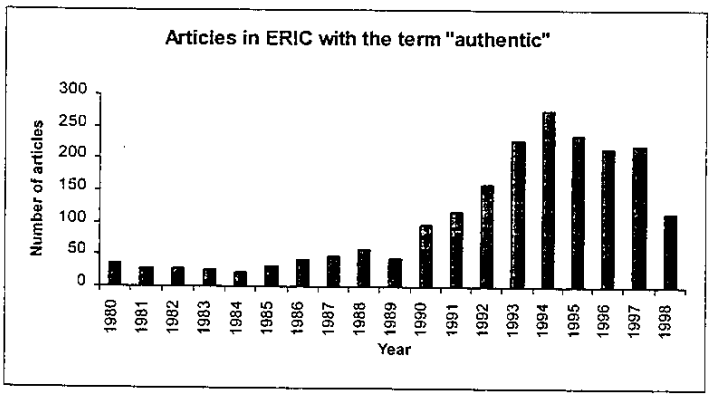

Figure 2. The number of English-language citations using the word "authentic" rose dramatically beginning in 1990

The idea of authentic education, as described by Wiggins and Newmann (and later by others in an Educational Leadership issue [volume 51 number 5] in 1993 on Authentic Learning—see Newmann, 1991; Newmann & Wehlage, 1993; Wiggins, 1993) was that education reform needs to focus on helping students learn to develop disciplined habits of thinking (disciplinary authenticity) by creating knowledge meaningful to themselves (personal authenticity) in contexts that have meaning in the world beyond school (real-world authenticity), and on the role that alternative assessments can play in that process (authentic assessment). These theorists, in other words, presented a vision of authentic learning that combined the different kinds of authenticity described above. There have been some interventions that manage to encapsulate this holistic view of authentic education (see, e.g., Schack, 1993). But judging from the literature on authentic education, work has tended to focus on the different aspects of authenticity in isolation.

This suggests that an effective learning environment needs to be not just "authentic" in one of the ways described in the literature (personal, real-world, disciplinary, or authentic assessment). Effective learning environments need to have all of the "kinds" of authenticity described by theorists. A successful environment will have what we call "thick authenticity." By analogy to

Geertz' well-known concept of "thick description" as description rich enough in detail to make meaningful interpretation possible (Geertz, 1973),[3] "thick authenticity" refers to activities that are personally meaningful, connected to important and interesting aspects of the world beyond the classroom, grounded in a systematic approach to thinking about problems and issues, and which provide for evaluation that is meaningfully related to the topics and methods being studied. In some ways, perhaps, this sounds like it is merely common sense. But the number of articles that neglect one or more of these aspects of authenticity suggests that the importance of thick authenticity is a message that bears repeating.

The world beyond the classroom, grounded in a systematic approach to thinking about problems and issues, and which provide for evaluation that is meaningfully related to the topics and methods being studied. In some ways, perhaps, this sounds like it is merely common sense. But the number of articles that neglect one or more of these aspects of authenticity suggests that the importance of thick authenticity is a message that bears repeating.

NEW MEDIA AND THICK AUTHENTICITY

Discussions of new media and education often focus on stereotypical—and we believe not very effective—views of computers and other new technology in learning. In particular, many proposed uses of computers for learning focus on doing the "same old things" but with new technology in place of more "old fashioned" pencils, paper, and people. So, for example, most "computer-aided instruction" programs aim to deliver traditional instruction that is customized for an individual student using a computer: a kind of technological tutor (see Dreyfus & Dreyfus, 1986). Tests are increasingly administered by computer, but the tests themselves are not substantially different. And debate continues about whether and when to allow students to use calculators to solve problems (see Pea, 1993) without always acknowledging that the deeper questions are about the nature of the mathematical problems being addressed. When interventions based on views such as these fail to produce dramatic results, critics begin to ask: "Do computers make a difference in education?" (see Papert, 1991.)

We believe that computers *can* make a difference, but only if they are used to restructure the processes of formal learning in far more profound ways. In this section of the paper we suggest that computational media have the potential to create thickly authentic learning environments of the kind described above—and in fact that these new media are particularly well-suited to

restructure learning in this way. Computers by themselves are not transformative; but the learning environments they help us to create may be. Thus we also suggest that the concept of thick authenticity provides a useful framework for thinking about how to make effective use of computers to support learning. To make this argument, we present what is admittedly a preliminary overview of the relationship between thick authenticity and new media. A comprehensive account of new media and thick authenticity is clearly beyond the scope of this paper. In the following pages we look at three particular aspects of computational media (connectivity, modeling, and representational pluralism). In each case we argue that the aspects of computational media make it possible—and in some cases necessary—to think holistically and simultaneously about personal, real-world, and disciplinary authenticity, as well as about authentic assessment (see Figure 3). New media provide a rich opportunity for thinking about thick authenticity, and the concept of thick authenticity in turn provides a powerful perspective for understanding the educational impact of new media.

		Aspects of Authenticity			
		Personal	**Real-world**	**Disciplinary**	**Assessment**
Aspects of Computational Media	**Connectivity**	• learners can take pride in authorship for a wide audience • connectivity cancreate new communities	• connectivity provides an audience beyond peers and teachers • connectivity provides increased access to information	•learners can get feedback from experts in fields they are studying	• the need to communicate ideas encourages externalization of understanding
	Modeling	• in modeling, learners construct expressive representations of experience	• learners can investigate complex systems	• learners can explore new theories of complexity	• external computational models reflect internal mental models
	Representational Pluralism	• computational media support multiple learning styles • learners can make connections to more subjects	• learners can use the same tools as professionals • learners can work on more complex problems	• computational media suggest a reexamination of traditional disciplines	• computational media provide multiple ways to express understanding

Figure 3. Computational media and thick authenticity

Connectivity

As the title of *The Connected Family* (Papert, 1996)—Seymour Papert's book on computers and learning—suggests, the interconnectedness of computational media has many important implications for education. Through the Internet (and particularly through the World Wide Web), connected media provide access to a public forum in which students can gather information, discuss ideas, publish the products of their work, and participate in a community of researchers and learners.

One effect of this connectivity is to give learners a personal stake in the learning process. Research suggests that in general students take pride in the public presentation of their writing (see Brand, 1992; Holmes & Moulton, 1994). Several authors have argued that publication of student work on the Web has positive effects overall, such as increased motivation and willingness to engage in revision to produce a quality product (Guhlin, 1996; Maring et al., 1996). This personal authenticity through connectivity is enhanced by the creation of technologically-supported communities in which learning takes place. In the CSILE project, for example, students use technology to construct a database of shared knowledge and understanding (Rowley, 1994; Scardamalia et al., 1987). The MOOSE Crossing project provides a multi-user domain (MUD) where children can learn computer programming skills through the collaborative construction of a virtual environment (Bruckman, 1994). In both of these examples, the presence of a community gives individual students a personal stake in the learning process: they are building understanding with and for people they know.

In addition to providing a forum and a community for personal authenticity, the connectivity of computational media offer opportunities for students to connect to the world outside the classroom—to provide real-world authenticity to learning activities. Web and desktop publishing give students access to an external audience for their work (Guhlin, 1996; Maring et al., 1996). Online databases and websites also make it possible for students to research topics that would otherwise be inaccessible. The connectivity of new media provides access to information that is not available in many school (or town) libraries—particularly on topics of interest to the community beyond the school (see Bilan, 1992; Papert, 1996, as well as the example below from Coulter, 1997).

The connectivity of computers supports disciplinary authenticity by giving students access to experts in a field. This may be through a cognitive apprenticeship model using chat rooms and listservs as students work with experts to solve problems (Farquhar et al., 1996), or through email access to

experts for online mentoring as in the Electronic Emissary Project (Sanchez & Harris, 1996). Access to experts and to real-world data provide a natural combination, so that students might, for example, pick a migratory animal and track movements of a particular herd through a season using resources available on the Internet. Questions that arise about the data and its interpretation can be directed to biologists and other experts who participate in the research students are using (see Coulter, 1997 for a more complete description of such a project). Through such interactions, students can learn how scientists frame and answer questions about animal behavior and ecological systems.

Connectivity also supports more authentic forms of assessment. Projects such as CSILE that support the social construction of knowledge do so, in part, by making knowledge construction overt. The process as well as product of learning is available for review, giving students an opportunity to benefit from feedback on the process as well as the product of their learning (Scardamalia et al., 1987). Sprague argues that tangible products in general are useful tools for aligning learning with evaluation (Sprague, 1993). Web pages or other digital products can similarly be the cornerstone of an integrated process of learning and assessment.

Modeling

Another aspect of computational media that has been given increasing attention in recent years is the ability of computers to provide a platform for modeling complex phenomena in ecological, biological, physical, and social systems. In some instances, students are given pre-constructed models that they can explore by changing parameters and watching the results. Potentially more transformative applications of computer modeling ask students to construct their own models of the world around them.

From the point of view of personal authenticity, this latter use of modeling is particularly powerful. Simulation as a process of construction provides learners with a sense of engagement in the model—they are invested in the simulation as a product of their own work. This personal connection to a model as a consequence of the construction process has been observed in both physical and virtual simulations using computational media (Resnick, Bruckman, & Martin, 1996). Bliss and Ogborn (1989) describe systems for constructing models as "expressive tools," suggesting that such applications give users the opportunity to explore their own understanding of a phenomenon by making an external model of it. Work by Draper argues that this expressive mode of learning gives students positive feelings towards their work (Draper, 1990).

For obvious reasons, computer simulations provide students with an opportunity to explore complex phenomena that are not easily studied using more traditional tools and methods. Students can construct models to explore social phenomena such as traffic flow, or biological systems such as ant colonies and slime molds, with the tool StarLogo (Resnick, 1994a; Resnick, 1994b). Students can create physics simulations using Logo Microworlds (Papert, 1980; Papert, 1993) or SimCalc (Kaput & Romberg, in preparation; Kaput, 1996; Kaput & Roschelle, in press), or models of population biology and ecology using Stella (Doerr, 1996). Commercial software also exists whereby students can explore pre-existing models of a wide variety of phenomena, from city management to evolutionary biology and geology (see Starr, 1994). Modeling thus extends the learner's reach into topics of interest and importance in the would beyond the classroom.

This extension of subject matter through modeling also supports a discipline-based approach to learning. In general, modeling activities cut across traditional disciplinary boundaries. But the process of investigating phenomena through simulations has its own coherent theories such as systems dynamics (Forrester, 1968), or decentralized thinking (Resnick, 1994a; Resnick, 1994b). Modeling is becoming an increasingly important mode—in some fields the dominant mode—of scientific inquiry, combining both synthetic and analytic aspects of formal understanding (Hut & Sussman, 1987). Modeling activities thus provide a way for students to learn about phenomena within a coherent (albeit new) theoretical framework.

Finally, proponents of modeling as a means of understanding systems point out that the process of constructing a model provides an external object that represents a student's understanding of the phenomenon in question. Some authors suggest that the external model can be interpreted as a map of the student's own internal model of the concepts in question (Coon, 1988; Webb & Hassell, 1988). In any case, the construction of a model provides a means for assessing a student's work that is directly connected to the processes of learning and production—and thus is an example of authentic assessment (see also Doerr, 1996).

Pluralism

Computers provide a range of traditional and non-traditional ways of representing and solving problems, making both old and new techniques more powerful and more accessible. To put the matter more precisely, we might say that computational media change the balance of power among representations, creating new representations and making old representations

more or less powerful (Kaput, 1992). For example, students can approach questions in geometry using traditional Euclidean, pencil-and-paper methods. But they can also use a dynamic exploration tool such as the Geometer's Sketchpad, or a concrete application of differential geometry such as Logo. Problems in physics can be solved using equations like F=ma, or though a model of the interactions of individual particles in *StarLogo,* or using difference equations and repeated iterations in a spreadsheet. Computational media create, in other words, a range of choices in representational systems by making powerful techniques more accessible to students.

Turkle and Papert (1990) describe one consequence of this multiplicity of representational options as "epistemological pluralism." They point out that learners using computational media can approach problems in multiple ways; so they can choose a style that is suited to their own particular cognitive strengths. Without computational representations, some problems and issues such as predator/prey interactions could only be explored using abstract and formal methods of inquiry such as differential equations. But new representations make it possible for concrete thinkers to approach such problems in rich and meaningful ways, using, for example, difference equations embedded in a graphical modeling environment such as Stella (see Peterson, 1985). In this way, representational pluralism makes it possible for students to find personal connections to subjects that they might not find accessible using traditional media, thus supporting personal authenticity.

Access to a wider range of powerful representations also supports real-world authenticity. New media make it possible for students to tackle "real" problems and their attendant complexity and difficulty at a young age. And in many cases, students can use the same tools that professionals use in accomplishing these tasks. Students can publish their own newspaper, newsletter, or magazine using the same desktop publishing software that graphic designers use (Brand, 1992). Alternatively, students can produce pictures using commercial image manipulation software such as *Photoshop*, or create a animated features using *MacroMedia Director*. Recently, a group of students used the *Geometer's Sketchpad* to produce a new publishable theorem in Euclidean geometry (Litchfield et al., 1997). New media make it possible for students to engage with a wider range of experiences that have meaning beyond the classroom.

The relationship between representational pluralism and disciplinary authenticity is somewhat more complex. The presence of new (and newly powerful) representations challenges and changes our understanding of traditional disciplines. The K through 12 curriculum has been slow to introduce film and media studies to students—offering instead English classes that focus on more traditional forms of literary expression (Paquette, 1996). But

example, students can approach

when so much information comes to students through visual media, the power of television and video seem to demand a reevaluation of what it means to be literate. Similarly, in mathematics education, theorists suggest that mathematics in a digital age should be less about mastering the algorithms of one representational system (pencil-and-paper computation and algebra) and more about the process of re-representing problems in various representational systems (Kaput, 1992). There are those who rightly point out that as computers replace pencil and paper, intellectual pursuits will change. But, as Davis and Hersh (1982, p 33) point out, "they are wrong in thinking that pencil and paper... [are] ideal, and that what replaces [them] is not viable." New representations challenge traditional disciplines; but in doing so they force learners—and educators—to look closely at what it means to think in a disciplined way.

Finally, pluralism in assessment grows directly from the idea of epistemological pluralism. The presence of many different means of representing—and thus expressing—understanding means that students can demonstrate their learning in a variety of ways. Different means of expression will naturally be more appealing to some students rather than others depending on their learning styles. The representational pluralism of computational media makes it possible to decouple a particular mode of representation from the assessment of a student's underlying understanding of a concept. I can show that I understand the historical significance of the Battle of Hastings in writing or through an interactive video presentation—my ability to express my thinking about a subject is not limited by my ability use one particular medium of expression. On a deeper level, theorists argue that, in fact, the very notion of "understanding" means the ability to express an idea in multiple ways (Perkins & Blythe, 1994): representational pluralism thus supports authentic assessment in a very profound way by making it possible for students to reflect their thinking an a variety of symbolic systems.

Disclaimers

This section of the paper clearly does not provide a comprehensive overview of computation and authentic learning. There are certainly aspects of computational media other than connectivity, modeling, and representational pluralism that can help create thick authenticity. Perhaps more important, this look at computation and thick authenticity is incomplete because connectivity, modeling, and representational pluralism are clearly not, by themselves, sufficient to create an authentic learning environment. Rather,

the point of this section of the paper has been to explore how computational media can be a powerful tool for the creation of thickly authentic learning environments. In at least three different ways (connectivity, modeling, and representational pluralism), properties of new media can contribute *simultaneously* to important components of authentic learning (personal, real-world, disciplinary, assessment). When used in appropriate ways, in appropriate practical and theoretical contexts, computers can help create environments for thickly authentic learning.

CONCLUSION

The term "authentic" has become something of a buzzword in recent years when applied to educational interventions. It is applied somewhat loosely and, as described above, inconsistently to a wide range of theoretical and practical work. Here we suggest that the concept of authenticity should not be abandoned, but analyzed more closely. A more comprehensive view of "authenticity" provides a potentially powerful framework for thinking about new media and education—and new media in turn provide a particularly rich context for authentic learning.

An analysis of the literature on authentic education suggests that there are four identifiable "kinds" of authentic learning: (a) learning that is personally authentic for the learner, (b) learning that is authentic in its relation to the real-world outside of school, (c) learning that provides an opportunity to think in the authentic modes of a particular discipline, and (d) learning where the means of assessment are an authentic reflection of the learning process itself. Each of these kinds of authenticity, on its own, has contradictions and problems associated with it. We argue here for a "thick authenticity," where learning environments have *all* of these aspects of authentic learning: personal, real world, disciplinary, and assessment.

Computational media present both a challenge and an opportunity in the creation of thickly authentic educational environments. On the one hand, computers and other new media can help create learning environments that are personally meaningful to learners, connected to the real world, theoretically sound, and where feedback is relevant to the learning process. New media put powerful tools in the hands of students—making it possible for them to research, collect data, study and search databases, and organize and present their findings in more complex situations and more personally meaningful ways than was possible 10 or 20 years ago. New media make it possible for students to deal with the messiness (and excitement) of grappling

been to explore how computational
ion of thickly authentic learning en-
/s (connectivity, modeling, and rep-
ew media can contribute simul-

with compelling problems at a young age. Computers can be a useful tool for educators looking to make learning more meaningful and more accessible to students.

On the other hand, computational media challenge the dominance of the traditional disciplines as the most meaningful and appropriate—as the most authentic—ways of understanding the world. Computational learning environments can provide students with personal connections to their work and with ways of connecting their learning to the broader world. The connnectivity of new media makes it possible for students to communicate with experts in various disciplines. But computers also let students think about new problems and think about old problems in new ways, such as the investigation of complex systems and the creation of new means of expression. Designers of computational learning environments need to think carefully about how students are going to receive feedback on their work that is relevant to their learning process—and about how this feedback will help students develop a framework of intellectual discipline for their work.

The idea of thick authenticity as the simultaneous creation of personal, real-world, assessment, and disciplinary authenticity thus provides a potentially useful guide for educators trying to design compelling and transformative learning environments—particularly environments that capitalize on the potential of computer technology for learning.

References

Archbald, D.A., & Newmann, F.M. (1988). *Beyond Standardized Testing: Assessing Authentic Academic Achievement in the Secondary School.* Reston, VA: National Association of Secondary School Principals and National Center on Effective Secondary Schools.

Baron, J.B., & Wolf, D.P. (Eds.). (1996). *Performance-Based Student Assessment: Challenges and Possibilities.* Chicago: University of Chicago.

Bilan, B.J. (1992). *Computer Simulations: An Integrating Tool.* Paper presented at the Annual Society for the Advancement of Gifted Education (SAGE) Conference, Calgary, Alberta.

Bliss, J., & Ogborn, J. (1989). Tools for exploratory learning. *Journal of Computer Assisted Learning, 5*(1), 37-50.

Brand, W. (1992). *Expanding Writing Opportunities for Elementary School Children and Assisting Teachers' Knowledge of the Writing Process.* Unpublished doctoral dissertation, Nova University.

Bruckman, A. (1994). *Programming for Fun: MUDs as a Context for Collaborative Learning.* Paper presented at the Annual National Educational Computing Conference, Boston, MA.

Chessick, R.D. (1988). A comparison of the notions of self in the philosophy of Heidegger and the psychoanalytic self psychology of Kohut. *Psychoanalysis & Contemporary Thought, 11*(1), 117-144.

Cizek, G.J. (1991). Confusion effusion: A rejoinder to Wiggins. *Phi Delta Kappan, 73*(2), 150-153.

Coon, T. (1988). Using STELLA simulation software in life science education. *Computers in Life Science Education, 5*(9), 65-71.

Cossentino, J., & Shaffer, D.W. (in press). The math studio: harnassing the power of the arts to teach across disciplines. *Journal of Aesthetic Education.*

Coulter, B. (1997). Tracking Migratory Animals: Going Online for Environmental Education. *Green Teacher*(53), 20-21.

D'Ambrosio, B. S. (1995). Implementing the Professional Standards for Teaching Mathematics: Highlighting the Humanistic Dimensions of Mathematics Activity through Classroom Discourse. *Mathematics Teacher, 88*(9), 770-772.

Davis, P.J., & Hersh, R. (1982). *The mathematical experience*. Boston: Houghton Mifflin.

Denman, C. (1995). Writers, Editors, and Readers: Authentic Assessment in the Newspaper Class. *English Journal, 84*(7), 55-57.

Dewey, J. (1938). *Experience and Education*. New York: Collier Books.

Doerr, H.M. (1996). STELLA Ten years later: A review of the literature. *International Journal of Computers for Mathematical Learning, 1*(2), 201-224.

Draper, F. (1990). Learner directed systems: A successful example. *System Dynamics Review, 9*(2), 209-213.

Dreyfus, H.L., & Dreyfus, S.E. (1986). *Mind over machine : the power of human intuition and expertise in the era of the computer*. New York: Free Press.

Engel, B.S. (1994). Portfolio assessment and the new paradigm: New instruments and new places. *Educational Forum, 59*, 22-27.

Farquhar, J.D., et al. (1996). *The Internet as a Tool for the Social Construction of Knowledge*. Paper presented at the National Convention of the Association for Educational Communications and Technology, Indianapolis, IN.

Fenn, R. K. (1992). *The endangered self*. Princeton, NJ: Princeton Theological Seminary.

Forrester, J. (1968). *Principles of Systems*. Cambridge: MIT Press.

Geertz, C. (1973). *The Interpretation of Cultures: Selected Essays*. New York: Basic Books.

Goldman-Segall, R. (1989). Thick descriptions: A tool for designing ethnographic interactive videodisks. *SIGCHI Bulletin (Special Interest Group on Computer Human Interaction), 21*(2), 118-122.

Goldman-Segall, R. (1991). A multimedia research tool for ethnographic investigation. In I. Harel & S. Papert (Eds.), *Constructionism* . Norwood, New Jersey: Ablex.

Goldman-Segall, R. (1997). *Points of Viewing Children's Thinking: A Digital Ethnographer's Journey*. Mahwah, NJ: Lawrence Erlbaum.

Guhlin, M.J. (1996). The writing-technology connection. *Technology Connection, 2*(9), 12-13.

Havens, L. (1986). A theoretical basis for the concepts of self and authentic self. *Journal of the American Psychoanalytic Association, 34*(2) 363-378.

Heuscher, J.E. (1987). Love and authenticity. *American Journal of Psychoanalysis, 47*(1), 21-34.

Holmes, V.L., & Moulton, M.R. (1994). "I Am Amazine to See My Write in Print": Publishing from ESLStudents' Perspective. *TESOL Journal, 3*(4), 14-16.

Hut, P., & Sussman, G. (1987). Advanced Computing for Science. *Scientific American, 255*(10), 145-153.

Kaput, J., & Romberg, T. (in preparation). Mathematics worth learning in the 21st century.

Kaput, J.J. (1992). Technology and Mathematics Education. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* . New York: Maxwell Macmillan International.

Kaput, J.J. (1996). Overcoming physicality and the eternal present: cybernetic manipulatives. In R.S.J. Mason (Ed.), *Technology and Visualization in Mathematics Education* . London: Springer-Verlag.

Kaput, J.J., & Roschelle, J. (in press). The mathematics of change and variation from a millennial perspective: new content, new context. In C. Hoyles & R. Noss (Eds.), *Mathematics for a new millenium* . London: Springer Verlag.

Kobrin, D., Abbott, E., Elinwood, J., & Horton, D. (1993). Learning history by doing history. *Educational Leadership, 50*(7), 39-41.

Lafer, S., & Markert, A. (1994). Authentic Learning Situations and the Potential of Lego TC Logo. *Computers in the Schools, 11*(1), 79-94.

Lello, J. (1980). Using Popular Songs of the World Wars in High School History. *History Teacher, 14*(1), 73-41.

Litchfield, D., et al. (1997). Euclid, Fibonacci, and Sketchpad. *Mathematics Teacher, 90*(1), 8-12.

Maring, G.H., et al. (1996). Using the World Wide Web To Promote Literacy Development and Learning Communities: Guidelines and Directions for Teachers . Washington State University.

Martin, B., Kass, H., & Brouwer, W. (1990). Authentic science: A diversity of meanings. *Science Education, 74*(5), 541-554.

Myers, S. (1993). A Trial for Dmitri Karamazov. *Educational Leadership, 50*(7), 71-72.

Newmann, F. (1991). Linking Resturcturing to Authentic Student Achievement. *Phi Delta Kappan*, 458-463.

Newmann, F.M., & Wehlage, G.G. (1993). Five Standards of Authentic Instruction. *Educational Leadership, 50*(7), 8-12.

Papert, S. (1980). *Mindstorms: children, computers, and powerful ideas*. New York: Basic Books.

Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* . Norwood, NJ: Ablex.

Papert, S. (1993). *The children's machine: rethinking school in the age of the computer*. New York: Basic Books.

Papert, S. (1996). *The connected family: bridging the digital generation gap*. Atlanta, GA: Longstreet Press.

Paquette, W.A. (1996). *Literature, History, Film, Sam Malone, and the Research Paper*. Paper presented at the Annual Meeting of the College English Association, New Orleans.

Pea, R. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed Cognitions: Psychological and Educational Considerations* . Cambridge: Cambridge University.

Perkins, D., & Blythe, T. (199). Putting understanding up front. *Educational Leadership, 51*(5), -7.

Perrone, V. (199). How to Engage Students in Learning. *Educational Leadership, 51*(5), 11-13.

Peterson, S. (1985). Using STELLA in Environmental Education. *Environmental Education Report and Newsletter, 14*(2), 13-18.

Radford, D., Ramsey, L., & Deese, W. (1995). Demonstration Assessment: Measuring Conceptual Understanding and Critical Thinking with Rubrics. *Science Teacher, 62*(7), 52-55.

Resnick, M. (199 a). Learning about life. *Artificial Life, 1*, 229-2 1.

Resnick, M. (199 b). *Turtles, termites, and traffic jams: Explorations in massively parallel microworlds*. Cambridge: MIT.

Resnick, M., Bruckman, A m(U., & Martin, F. (1996). Pianos not stereos. *Interactions 3*(5), 0-50.

Reutzel, D.R., & Larsen, N.S. (1995). Look what they've m(.Udone to real chidren's books in the new basal readers! *Language Arts, 72*, 95-507.

Roeber, E., & Dutcher, P. (1989). Michigan's innovative assessment of reading. *Educational Leadership, 46*(7), 6 -69.

Rowley, P. (199). *Collaborative Technology for Revolutionary Classroom Structures*. Paper presented at the Annual National Educational Computing Conference, Boston.

Sanchez, B., & Harris, J. (1996). Online Mentoring—A Success Story. *Learning and Leading with Technology, 23*(8), 57-60.

Scardamalia, M., et al. (1987). *Computer Supported Intentional Learning Environments*. Paper presented at the Annual Meeting of the American Educational Research Association, Washington, DC.

Schack, G.D. (1993). Involving students in authentic research. *Educational Leadership, 51*(5), 29-31.

Shepard, L. (1989). Why We Need Better Assessments. *Educational Leade ship, 46*(7), -9.

Simon, M.A. (199). *Beyond Inductive and Deductive Reasoning: The Search for a Sense of Knowing*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Sprague, M.M. (1993). From Newspapers to Circuses—The Benefits of Production-Driven Learning. *Educational Leadership, 50*(7), 68-70.

Starr, P. (1994). Seductions of sim: Policy as a simulation game. *American Prospect* (17), 19-29.

Stepien, W., & Gallagher, S. (1993). Problem-based learning: As authentic as it gets. *Educational Leadership, 50*(7), 25-28.

Turkle, S., & Papert, S. (1990). Epistemological pluralism: styles and voices within the computer culture. *Signs, 16*(1), 128-157.

Ware, W.R. (1866). *Outline of a Course of Architectural Instruction.* Boston: John Wilson.

Webb, M., & Hassell, D. (1988). *Opportunities for computer based modeling and simulation in secondary education.* Paper presented at the First European Conference on Computers in Education-ECCE 88.

Wiggins, G. (1989a). Teaching to the (Authentic) Test. *Educational Leadership, 46*(7), 41-47.

Wiggins, G. (1989b). A True Test: Toward More Authentic and Equitable Assessment. *Phi Delta Kappan, 70*(9), 703-713.

Wiggins, G. (1993). Assessment: Authenticity, context, and validity. *Phi Delta Kappan, 75*(3), 200-214.

Williams, N. (1995). *The Comic Book as Course Book: Why and How.* Paper presented at the Annual Meeting of the Teachers of English to Speakers of Other Languages, Long Beach, CA.

Notes

1. Throughout this article, we refer to information about the ERIC database collected using the FirstSearch index in August 1996.
2. There were, of course, also articles (20% of the sample) that used "authentic" in their more usual sense, outside the context of a specific kind of educational intervention, as, for example, in "authentic Native Alaskan Dance."
3. Geertz' concept of "thick description" has been used by other authors in the context of education research (see particularly Goldman-Segall, 1989; 1991; 1977).