DOCUMENT RESUME

ED 482 131 IR 058 810

AUTHOR	Schaller, David T.; Allison-Bunnell, Steven
TITLE	Practicing What We Teach: How Learning Theory Can Guide Development of Online Educational Activities.
PUB DATE	2003-00-00
NOTE	18p.; In: Museums and the Web 2003: Selected Papers from an International Conference (7th, Charlotte, NC, March 19-22, 2003); see IR 058 801.
AVAILABLE FROM	For full text: http://www.archimuse.com/mw2003/papers/schaller/schaller.html/.
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Constructivism (Learning); Exhibits; *Instructional Design; Learning Activities; *Learning Theories; Museums; Online Systems; World Wide Web
IDENTIFIERS	*Interactive Exhibits; Interactive Systems; Virtual Museums

ABSTRACT

Since the World Wide Web became in 1994 the first new mass medium since television, online learning design has evolved at Internet speed, taking in less than a decade what it took exhibit design over a century to develop in sophistication. Although virtual exhibits consisting of pictures and text are still common, educational Web designers increasingly employ techniques borrowed from interactive exhibit developers, video game producers, and museum educators to create compelling activities that fully exploit the strengths of the new medium. Constructivist learning theory often informs these new approaches. However, transplanting learning theory from the classroom or museum environment to the Web poses unique challenges. This paper reviews several theories of learning and explores ways that the authors have tried to incorporate them into the development and design process for interactive Web sites. Constructivism underlies much educational practice in museums and is the basis for all of the learning theories surveyed in this paper. Each of these, however, clarifies, expands upon, or revises the notion of constructivism in ways that can help Web designers better conceptualize and execute their projects. Includes four tables and nine figures. (Contains 22 references.) (Author/AEF)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 482 131

PAPERS
Museums and the Web 2003

Practicing What We Teach: How Learning Theory Can Guide Development Of Online Educational Activities

David T. Schaller and Steven Allison-Bunnell,
Educational Web Adventures (Eduweb), USA

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

D. Bearman

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Register
Workshops
Sessions
Speakers
Interactions
Demonstrations
Exhibits
Events
Best of the Web
Key Dates
Charlotte

A&MI

Archives & Museum Informatics
158 Lee Avenue
Toronto Ontario
M4E 2P3 Canada

ph: +1 416-691-2516
fx: +1 416-352-6025

info@archimuse.com
www.archimuse.com

Search A&MI

Join our Mailing List.
Privacy.

Updated: March 13, 2003

Abstract

Since the World Wide Web became in 1994 the first new mass medium since television, online learning design has evolved at Internet speed, taking in less than a decade what it took exhibit design over a century to develop in sophistication. Although virtual exhibits consisting of pictures and text are still common, educational Web designers increasingly employ techniques borrowed from interactive exhibit developers, video game producers, and museum educators to create compelling activities that fully exploit the strengths of the new medium. Constructivist learning theory often informs these new approaches. However, transplanting learning theory from the classroom or museum environment to the Web poses unique challenges. In this paper, we review several theories of learning and explore ways that we have tried to incorporate them into our development and design process for interactive Web sites.

Constructivism underlies much educational practice in museums and is the basis for all of the learning theories we survey in this paper. Each of these, however, clarifies, expands upon, or revises the notion of constructivism in ways that can help Web designers better conceptualize and execute their projects. For example, Kolb's model of learning styles highlights the structure of the learning process. This model offers insight into how to make Web media go beyond the convergent/logical learning that comes easiest to computer-based learning, and to teach divergent, practical, and social learners. Similarly, Gardner's checklist of multiple entry points offers a valuable perspective on diversity in learning, prompting us to look for ways to engage various intelligences in one package. Most dramatically, Egan's notion of developmental "kinds of understanding" frees us from the strict constructivist demand to account for the concrete prior knowledge of our mostly anonymous online audiences. Instead of attempting that impossible feat, or ignoring the issue entirely, we can engage children's and adults' imaginative capacities with stories about profound abstractions, the limits of reality and experience, and our place in the world.

Keywords: Learning Theory, Constructivism, Multimedia Web Development, Online Learning, Evaluation and Research

Introduction

For the purposes of this paper, we wish to offer a fairly demanding definition of "interactivity" as applied to online learning materials. Given the present pervasiveness of random-access devices, from audio CD-players to even the most rudimentary Web sites, merely being able to choose what to see or read is no longer very challenging to conceptualize or produce. Reaching higher, we see the paragon of interactivity involving at least some of the following, non-mutually-exclusive elements:

- Enabling two-way communication between real people, whether in real time or not. Failing that, simulating the richness of two-way person-to-person communication with the computer via narrative devices, visual and interface design, and the underlying information architecture is a common

IR058810

BEST COPY AVAILABLE

way to automate what is otherwise time and resource-intensive.
- Offering the user "productive decision-making opportunities" (Strohkorb 2002). This means going beyond offering menus of choices to select from, and involves providing an infrastructure for helping the users to construct their own chain of inference and meaning. Giving the users the ability to experience the consequences of their choices is at the heart of state-of-the-art interactivity and game-based learning theory (Prensky 2001, Schank 1992).
- Giving the users something to *do* rather than something to *see*. Manipulation of objects and ideas that produce a new construct is crucial to a strong form of interactivity (see discussion of "Creative Production" activities below). Merely manipulating an interface widget is not in and of itself interactive in a meaningful way.

Defining what makes a Web site "educational" is just about as slippery as nailing down what counts as interactive. Again, we favor a strong definition that includes these basic characteristics:

- Learning goals or outcomes that can be explicitly articulated by the designers (if only after the fact)
- A clearly focused subject domain
- Scaffolding to help the users develop a skill or increase knowledge under the structured guidance of the program. Thus, a database, by itself, may be a tremendous research tool, but it may not actively help the users develop expertise in using it or understanding the subject domain (Jonassen *et al*, 1999).

The learning theory most commonly known as constructivism holds that learning "is not a simple addition of items into some sort of mental data bank but a transformation of schemas in which the learner plays an active role and which involves making sense out of a range of phenomena" (Hein 1998). Designing learning experiences that facilitate such active meaning making while engaging a generation raised on a steady diet of video games and fast-paced television is the ongoing challenge facing formal and informal educators alike. Computers add to the challenge, since it is all too easy to design computer programs that substitute sophisticated but passive representations for the healthy (and fun) cognitive work of learning. How can we, as practitioners of educational Web design, apply current theories of learning to our development process and final products?

One Size Fits None

While the theoretical and descriptive frameworks of learning theory vary widely, there is consensus that people perceive and process information in many ways. Some of these theories apply general personality theory to learning while others derive from studies of the learning process itself. Each seems coherent enough on its own. But can they all be right? Should we try to accommodate them all in our development philosophy and process? Guild and Garger (1998) suggest that we are in a pre-paradigmatic phase of learning style research. The blind researchers have each described a different part of the elephant, but have not yet synthesized their findings into a picture of the whole beast.

Of the many theories about learning styles, we have found David Kolb's experiential learning theory (ELT), first developed in the 1970s, to offer us valuable insights. Kolb emphasizes the importance of experience in the learning process and draws on research by Dewey and Piaget, among others, to identify two major dimensions of learning: perception and processing. Each dimension has two extremes: perception ranges from concrete experience to abstract conceptualization, and processing ranges from reflective observation to active experimentation. These two dimensions form a four-quadrant model (Figure 1).

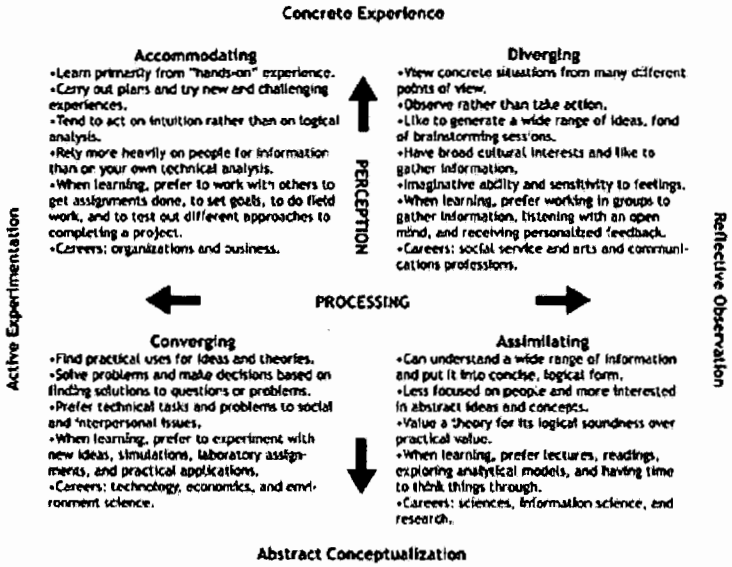


Figure 1. Kolb's model of learning styles. Adapted from Kolb et al. 1999.

Kolb's model of learning styles reveals another challenge: how to engage these various ways of learning via a flat computer screen. The Web as an "information superhighway" is ideal for Assimilating Learners who prefer reading and reflective analysis. But what about Accommodating Learners who prefer social environments, or Divergent Learners who need to brainstorm and obtain personal feedback? Can online activities effectively engage them? We are currently planning a research study to investigate these questions further, but we have already made some attempts to put Kolb's theory into practice. *The Artist's Toolkit* (**http://www.artsconnected.org/toolkit**), developed with The Minneapolis Institute of Art and the Walker Arts Center, offers four ways to explore a series of art elements and principles (Table 1).

Artists' Toolkit Component	Perception-Processing Axis	Learning Style
Watch: Short animations that demonstrate the concept using an artwork from the institutions' collections (Figure 2).	Reflective Observation	**Diverging and Assimilating:** -View concrete situations from many different points of view. -Observe rather than take action. -Less focused on people and more interested in abstract ideas and concepts. -When learning, prefer lectures, readings, exploring analytical models, and having time to think things through.
Find: Examine three artworks and drag	Active Experimentation	**Accommodating and Converging:** -Learn primarily from "hands-

BEST COPY AVAILABLE

labels of each concept over to instances of them in the art (Figure 3).		on"experience. -Solve problems and make decisions based on finding solutions to questions or problems. -Prefer technical tasks and problems to social and interpersonal issues. -When learning, prefer to experiment with new ideas, simulations, laboratory assignments, and practical applications.
Create: Apply the concepts in an original composition with an open-ended picture-making tool. Add lines and shapes to a canvas and arrange them to create a picture (Figure 4).	Concrete Experience	**Accommodating and Diverging:** -Learn primarily from "hands-on"experience. - Tend to act on intuition rather than on logical analysis -Like to generate a wide range of ideas, fond of brainstorming sessions. -Imaginative ability and sensitivity to feelings.
Encyclopedia: Study the concepts in more depth through expository text and example artworks (Figure 5).	Abstract Conceptualization	**Assimilating:** -Can understand a wide range of information and put it into concise, logical form. -Less focused on people and more interested in abstract ideas and concepts. -Value a theory for its logical soundness over practical value. -When learning, prefer lectures, readings, exploring analytical models, and having time to think things through.

Table 1. The Artists'Toolkit components and targeted learning styles. The first three components above were designed for K-5 grade students; the fourth one is a didactic resource for older students and teachers.

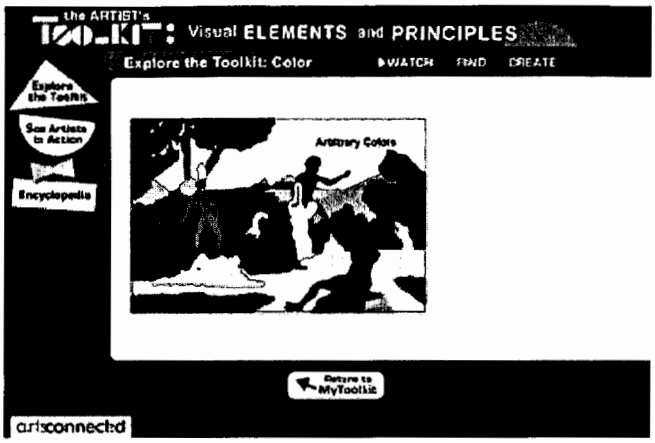


Figure 2. Watch module.
www.artsconnected.org/toolkit/watch_color_arbitrary.cfm

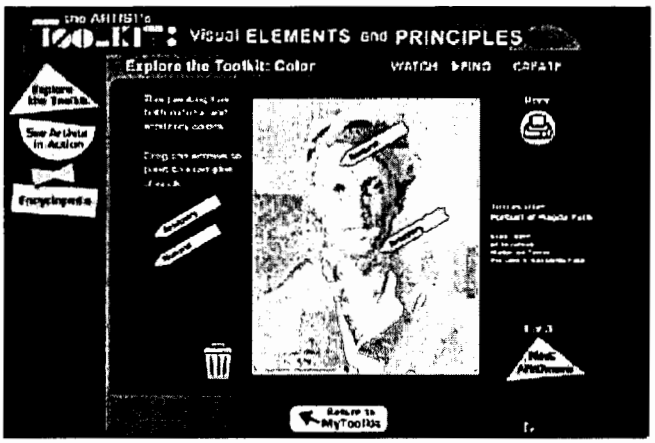


Figure 3. Find module.
www.artsconnected.org/toolkit/find_color_arbitrary.cfm

BEST COPY AVAILABLE

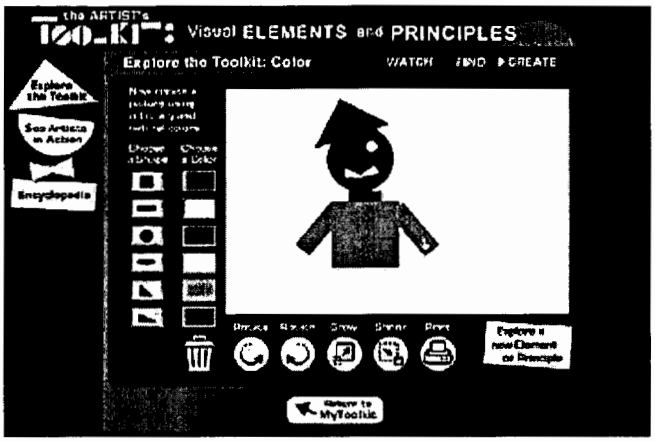


Figure 4. Create module.
www.artsconnected.org/toolkit/create_color_arbitrary.cfm

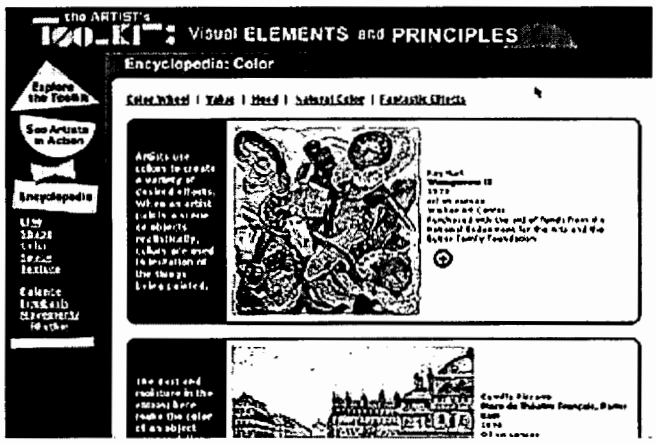


Figure 5. Encyclopedia module.
www.artsconnected.org/toolkit/encyc_colornatural.html

Connecting Learning Styles and Activity Types

By examining differences in mental processing preferences, Kolb's model also suggests ways that online activities can engage different types of learners. We have hypothesized plausible links between Kolb's styles and our own typology of online activities (Schaller *et al.*, 2002) as follows:

Role-Play activities allow users to adopt a persona different from their own, giving them the ability to do things they cannot ordinarily do (e.g. break natural or societal laws, experience people and places normally out of reach). They can also interact with other characters, whose behavior either may be scripted or controlled by other players. (True social interaction on the Web, i.e. direct communication with other people, is one of its key strengths, but it also poses many challenges with a school-age audience, from privacy concerns to risks of inappropriate communication. This means that many activities that could in principle take advantage of the technology to connect real people with one another must substitute interaction with the program.) We hypothesized that the Role-Play activity type may appeal to those with a strong Accommodating

BEST COPY AVAILABLE

learning style.

Simulation employs a model of the real world that users can manipulate to explore a system. It involves direct engagement with representations of data with some degree of generalization or abstraction. While many activities may have an underlying simulation or model that generates the activity decision tree, "simulation" as used here is explicitly framed as such in its presentation to the user, and is used to develop conceptual understanding of a complex system. We hypothesized that this activity type may appeal more strongly to people with either an Assimilating or Converging learning style.

Puzzle/Mystery involves analysis and deductive or inductive reasoning to reach a logical solution. The user relies on evidence from people, nature, or reference material provided by the activity to solve the problem. We hypothesized that this activity type may be more appealing to people with either an Assimilating or Converging learning style.

Creative Production emphasizes both open-ended self-expression and the application of subject knowledge and concepts to building some kind of product such as a story, a picture, a movie, etc. We hypothesized that this activity type may appeal more often than the other types to the Divergent learning style.

With these associations in mind, we sought to offer a variety of learning experiences in a suite of educational Web activities, *Shedd Educational Adventures (SEA)* (www.sheddaquarium.org/sea), developed in partnership with the John. G. Shedd Aquarium. We should emphasize that we do not see each activity type appealing solely to a single learning style. Rather, different learners will utilize each type of activity differently. As developers, recognizing the strengths of each activity type and the learners it appeals to most strongly helps us avoid building activities that appeal merely to our *own* learning styles.

Squish the Fish (Figure 6) is an interactive role-play story for primary-grade children (grades K-2). Although users do not explicitly assume the role of Squish, they guide him through a dangerous journey across a coral reef. Squish has the ability to shape-shift and color-shift to avoid predators, and users can vicariously go along for the ride. While experiencing no social interaction with other people in real time, users do meet a variety of talking fish and other undersea creatures that personify the various adaptations that Squish uses to stay alive, thus attempting to engage Accommodating learners.

Figure 6. Scene from Squish the Fish.
www.sheddaquarium.org/SEA/interactive_module.cfm?id=8

BEST COPY AVAILABLE

Build-a-Fish (Figure 7) is a simulation with a touch of creative production, intended for upper primary students (grades 3-5). Players design a fish and then navigate it around a detailed coral reef, trying to eat other fish and avoid being eaten in turn. This pragmatic challenge engages Convergent Learners, while Assimilating Learners can review didactic content to inform their hypotheses of which fish designs will be most successful.

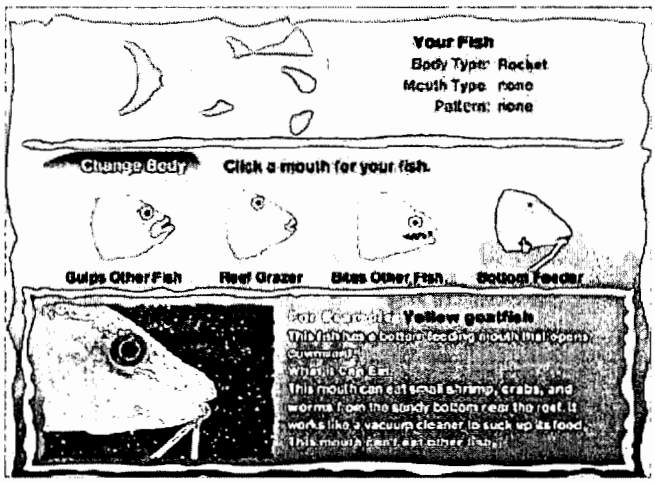
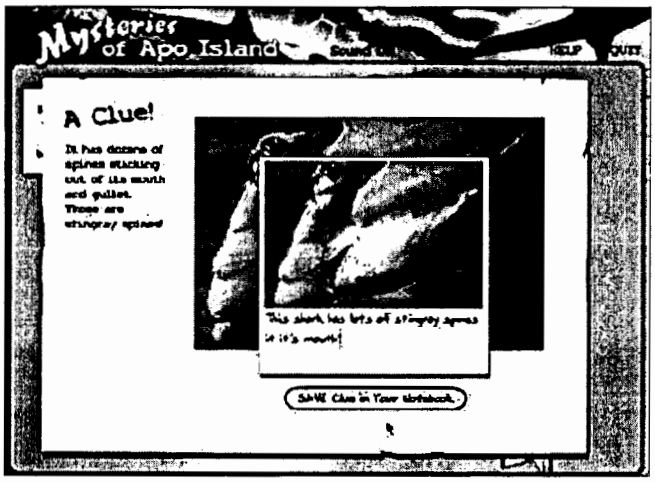


Figure 7. Mouth-types choice screen from Build-a-Fish
www.sheddaquarium.org/SEA/interactive_module.cfm?id=7

Mysteries of Apo Island (Figure 8) is designed for middle school students (grades 6-8), and offers clues that the user must analyze and synthesize to solve a series of mysteries. While exploring a map of Apo Island in the Philippines, users encounter stories and personal observations of strange animal behavior. Each of these can be collected in the users' notebooks, where they can then compare the clues and sort them into groups by species. In this way the activity is an "open-ended mystery." While the clues do match up to correct solutions, users are not funneled toward solutions, as they would be in a branching story structure. Instead, users must use logical deduction to hypothesize solutions and then ask a local biologist to check their conclusions.



[Figure 8 Clue screen from Mysteries of Apo Island.
www.sheddaquarium.org/SEA/interactive_module.cfm?id=9

BEST COPY AVAILABLE

We initially planned to develop a simulation for the high school audience (grades 9-10). But due to conceptual issues (detailed below) and budgetary constraints, we turned instead to an interactive reference module. In *Conservation Investigation: Seahorses* (Figure 9), students can explore a conservation issue through primary and secondary sources and write a newspaper editorial based on their research. The students assume the role of investigative reporters and are offered a range of materials about seahorse conservation grouped according to how journalists might research the story: field observations, interviews, and library materials. In writing the final product, the students are guided by a template that encourages logical organization and solid evidence to supportheir opinion. This combines role-play and creative production elements, but in a less fanciful, more serious fashion for this more mature age group.

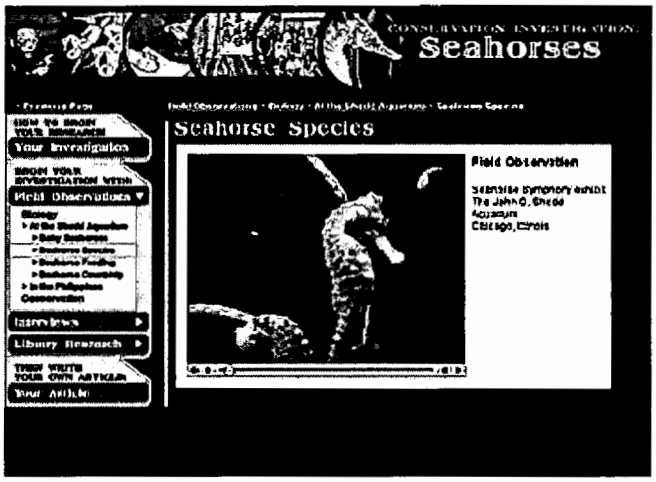


Figure 9. Seahorse video clip from Conservation Investigation: Seahorses. www.sheddaquarium.org/SEA/interactive_module.cfm?id=11

Integrating Learning Styles into One Activity

One of the challenges of using Kolb's framework is that while it is clear how to match a particular learning style with a particular activity type, Kolb offers less guidance in creating a single activity that can meet the needs of learners with multiple learning styles. Howard Gardner's theory of multiple intelligences has earned wide acclaim and regard from both formal and informal educators. By examining many cognitive modalities, his theory inspires us to stretch the Web's capabilities to engage many different kinds of learners. Table 2 shows how Gardner's Entry Point Approach outlines ways to provide multiple entry points to a single learning experience "to accommodate the different lenses through which learners see" (Davis and Gardner, 1993).

Entry Point	Learners respond to:
Narrative:	The story.
Numerical:	Numbers, statistics, and mathematical models, as well as musical rhythm.
Logical:	Logical propositions, syllogisms, narrative plot structure and cause and effect relationships.
Existential/Foundational:	Big questions about life, death and our place in the world.

BEST COPY AVAILABLE

Aesthetic:	Surface qualities of art and music, as well as other subjects, *i.e.* balance in an ecosystem, harmony in the built environment, etc.
Hands-on or Experiential:	Direct exploration, both physical and virtual, through experimentation, creativity, and immersive experiences.
Interpersonal:	Social interaction through cooperation, debate, and role-play.

Table 2. Howard Gardner's Entry Points for multiple intelligences (Gardner 1999).

Several researchers have explored these entry points in the museum context. Project Explore examined which entry points children and adults utilized at several children's museums, and found that Experiential was by far the most common, with Narrative a distant second and the rest even less frequently evoked (Please Touch Museum and Project Zero, 1998). Experiential is, of course, the easiest entry point to observe in a museum setting. But even in an exhibit with musical instruments, the Aesthetic entry point was rarely observed. The researchers concluded that this disparity may stem from either methodological issues or deeper questions of exhibit design or even young children's cognition.

For Shedd's SEA package, we considered how to design each online activity to contain multiple entry points (Table 3).

Activity	Entry Points	How users might engage entry points
Squish the Fish	**Narrative**	Responds to Squish's quest to travel across the reef to eat and to return home again.
	Aesthetic	Comparing examples of shape, color, and pattern adaptations. Reading the rhyming verse.
	Hands-on / Experiential	Trying an adaptation and seeing whether it protects Squish from Big Tooth Blob.
	Logical	Systematically testing each adaptation on various places on the reef.
Build-a-Fish	**Hands-on / Experiential**	Designing a fish and seeing whether it can eat and avoid being eaten on the reef.
	Logical	Systematically testing fish designs to see which does best in various places on the reef.
	Aesthetic	Considering shape and color differences in design options while designing fish.
Mysteries of Apo Island	**Narrative**	Responds to the story setup.
	Logical	Examining and comparing clues, identifying shared characteristics

		of clues. Comparing solutions to biologist's fact cards.
	Hands-on/ Experiential	Exploring the island map, sorting clues into groups.
Conservation Investigation: Seahorses	**Narrative**	Responding to journalist story framework.
	Logical	Recording, reviewing and analyzing research information and synthesizing into article.
	Interpersonal	Observing video clips of seahorses and interviews with biologists.

Table 3. Connections between Entry Points and Shedd SEA activities.

During pilot testing, naturalistically observed student behavior suggested that the entry points we intended for the activities were in fact used:

Squish. The target audience responded enthusiastically to the Narrative framework of Squish.

Build-a-Fish. Younger students (3rd grade) typically used the Hands-on entry point, experimenting with fish designs without logically considering the causes and effects of each choice. Middle school students, however, usually did prefer the Logical entry point and were often quite methodical in testing each combination of fish design options. Aesthetic engagement was seen in requests for a larger variety of fish body parts and colors to choose from. Further evaluation is required to determine whether the game was simply too challenging for third graders to use more logical approaches without teacher guidance or whether children favor different learning styles at different developmental stages.

Mysteries of Apo Island. Middle school students responded well to the Narrative entry point, sometimes making up their own scenarios about why a shark might behave in a way consistent with the clues. As is discussed below, younger middle school students had trouble with the Logical aspects of the activity, and frequently were unable to develop the chain of inference that would let them solve the mystery.

Conservation Investigation: Seahorses. Teachers evaluating this activity felt that the Logical guidance offered in structuring the research and writing exercise would be helpful and appropriate for this age level.

Kinds of Understanding

As noted above, current learning theory holds that learning involves a transformation of mental schemas, from flawed and incomplete to truer and more complete (Bransford *et al.* 2000). To facilitate such transformations most effectively, educators must understand their students' prior knowledge, experiences, and most critically, their misconceptions about the subject. Only by tackling such misconceptions directly can educators effectively help learners to overcome them and achieve a truer (more accurate) understanding of the world (Borun 1990, Hein 1998). Much of our knowledge of such misconceptions derives from Piaget's research. Indeed, much of contemporary learning theory is based on his work, which mainly investigated children's learning about the physical world and mathematics (Egan 1998). In such domains, hands-on experimentation

is invaluable as a way to bring "students' earlier models or misconceptions into sharp focus [through] an experience that directly challenges the viability of the model they have been favoring" (Gardner 1991). Exploring a parallel phenomenon in the humanities, Gardner discusses the persistence of stereotypes, scripts and simplifications such as "the 'bad man' theory" of history, even among well-educated college students (*Ibid.*). To transform such misconceptions, a strict constructivist approach would start with familiar and concrete objects and places before moving to the distant and abstract.

A teacher can discover her students' misconceptions and stereotypes from a class discussion at the start of a lesson. Similarly, museums conduct front-end research studies to ascertain their audiences' pre-existing knowledge and misconceptions and stereotypes (also called preconceptions and naïve notions) about a program or exhibit topic. This task is challenging enough when exhibits attract visitors of many ages and experiences. On the Web, which attracts learners of all ages in varying settings from around the globe, trying to determine pre-existing knowledge and misconceptions is even more daunting. When learning theory calls for an emphasis on what is familiar to learners, the challenge becomes difficult indeed.

Educational theorist Kieran Egan offers a way out of this dilemma by re-imagining what *kinds* of knowledge come naturally to learners at each stage of development (Egan 1988, 1992, 1998). He argues that our powerful imaginative capacities are much more effective (and affective) avenues to learning than the prosaic approaches advocated by Piaget's strictest adherents. Even young children have a deep (if difficult to articulate) understanding of certain profound abstract concepts such as good/bad, beauty/ugliness and survival/destruction. Medieval fairy tales and the *Star Wars* movies would have little hold on children if this were not the case. These abstractions have deep affective meaning for children (and adults) and thus are very powerful ways to present new material.

*While the first three phases occur fairly naturally in human development, the latter two require substantial guidance and support for an individual to achieve.

Kinds of Understanding	**Age**	**Concerns**	**Examples**
Somatic	Birth to three	Body abilities	Walking
Mythic	Three to eight	Binary opposites	*Star Wars* movies
Romantic	Eight to fifteen	Limits of reality and experience; heroes, idealism	*Guinness Book of World Records* Michael Jordan "Save the Earth"
Philosophic*	Fifteen to twenty	Systems and schema	Marxism
Ironic*	Twenty and up	Self-reflective	Post-modernism

Table 4. Egan's theory of developmental phases in learning style (Egan 1998).

Each new kind of understanding builds on previous stages. As young children, we begin to organize the world by dividing everything into binary opposites. Only after we have created basic categories can we start to refine our mental organization of the world, typically by exploring the extremes of reality (from the

tallest human to a hero who transcends limitations and adversity) to better understand our own place within this order. It is after gaining a sense of the range and variety of experiences that we start thinking about how they all relate to one another. The philosophic level propels the search for causal connections that have birthed theories from Marxism to the second gunman on the grassy knoll. Acquiring the ability to construct such general schema can trigger a period as a "true believer" with tunnel vision, but with some outside support, we can ultimately achieve Ironic understanding, or a deep appreciation that every theory contains some truth but none can claim to be The Truth. This doesn't mean that adults who have reached this phase can't enjoy an occasional *Star Wars* movie, for the "simplistic" theme of good vs. evil still resonates deep within us, but that we can appreciate it for what it is without then interpreting real international affairs through the same lens.

What Egan's theory offers us as designers of online learning experiences is valuable guidance about the kinds of abstractions people will find innately relevant and meaningful. We were inspired by these ideas during the development of the Shedd Educational Adventures online activities with the Shedd Aquarium. Since this project entailed producing online learning modules for five grade groups: K-2, 3-5, 6-8, 9-10, and 11-12, we kept Egan's kinds of understanding in mind during our development process, letting them inform the themes we developed and the stories we told.

Mythic Understanding and Squish the Fish

The learning goals for elementary grade activities centered on fish adaptations and easily lent themselves to stories of danger and survival. Squish the Fish and Big Tooth Blob, cartoon characters from Shedd's existing education materials, embody the struggle for survival which children so easily grasp. Squish must travel across the reef, looking for friends who have successful shape, color and behavioral adaptations to protect themselves from Big Tooth Blob. Children instinctively understand the binary opposites of safety and danger and this, rather than any reference to the concrete world of our child-audience, is the theme that carries the message.

Amplifying the safety-danger theme meant making Big Tooth Blob a pure predator with no sympathetic traits. However, since his name and appearance are more comical than threatening, he is portrayed as simply hungry, rather than as menacing or malevolent. Thus no one clamored to give Big Tooth's side of the story. With a subject such as history, resistance to binary stereotyping from either the target audience or teachers and subject experts would pose more problems.

The real question is whether the story is mythic *enough*. Using the term in a similar way, Rounds (2002) describes the tension between mythic and scientific thinking, arguing that museum visitors often interpret science content in mythic terms. The factual content is not what interests them. It is the meaning they can make from the stories that is important, and they judge those stories by their affective authenticity, not by their factual accuracy. The mythical aspect of the safety-danger theme in Squish gives the story some degree of affective authenticity, but our real goal centered on communicating the factual content about various organisms and their adaptations. Squish succeeds because it offers a scientifically credible mythic framework for the more abstract and emotionally neutral concept of adaptation as an evolutionary response to survival and predation. We want to emphasize that deploying a mythic theme that does not naturally stem from the content in an activity such as this will only undermine its educational value for the learner and its credibility with the teacher.

Romantic Understanding and The Mysteries of Apo Island

The Shedd's learning goal for this activity was shark biodiversity — showcasing "the many kinds of sharks and their fascinating adaptations and behavior." Exploring this theme through the romantic fascination with the exotic and bizarre ("the limits of reality and extremes of experience," in Egan's terms) was

straightforward enough, since there are plenty of odd shark adaptations and behaviors from which to choose. The challenge lay in taking it beyond a "trivia quiz" approach that might prove intriguing but would still consist of informational dead-ends. Our goal was to design an activity that leveraged the romantic fascination with exotica into a larger learning experience that developed synthetic reasoning skills. For that we turned to a mystery format. The trivia were made into clues that, if examined and integrated, provided the solutions to the mystery. Thus we hoped to foster a romantic understanding of shark biodiversity within a deductive reasoning process, thereby suggesting the path ahead to philosophic understanding.

Pilot testing indicated that shark exotica were indeed successful in engaging the students' attention. Some also responded quite enthusiastically to the deductive structure of the activity, while others (especially students at the lower end of the grade 6-8 target range) enjoyed the clues but found the mystery befuddling. That kind of synthesis is more characteristic of philosophic understanding, and so it shouldn't be surprising that some 12-year-olds found it too challenging.

In another example of Rounds' mythic-scientific distinction, we also found that students sometimes assumed the solution would focus on an *individual* shark rather than a shark species as a *group*. Students would spin their own stories about "a bad shark" that attacked the boat and other sharks, fantasizing many details that were quite out of character for the mystery itself. Of course, the mystery format (as well as most appearances of sharks in popular culture) encourages this interpretation. Our own scientific-mindedness had blinded us to the likelihood of this result. We have since emphasized the idea of species as groups in the activity text, but we await summative evaluation to see whether that makes any difference.

Philosophic and Ironic Understanding and an Ill-fated Simulation

Inspired by Sherry Turkle's call for "simulations that teach about the nature of simulation itself, that teach enough about how to build [your] own simulation that [you become] a literate 'reader' of the new medium," we decided to tackle just such an effort (Turkle 1997). Building on a coral reef management simulation already produced for Shedd, we imagined letting students "under the hood" of the simulation so they could tinker with its assumptions and parameters. We were motivated by our own awareness that every model has both descriptive power and predictive blind spots. We wanted students to be able explore how the hidden assumptions and underlying logic of a model can dramatically affect the simulation's portrayal of the real world.

However, presenting this concept to high school teachers in focus groups led us to abandon it. The teachers felt that orienting students in this age group to a model of ecosystem management, however simplified, was challenging enough. Layering additional complexity with the reflexive analysis of the model itself was more than students could handle, at least with such an unfamiliar subject. Consequently, we switched to a simpler and more traditional interactive reference format (*Conservation Investigation: Seahorses*), hoping to return to Turkle's challenge in the future. In retrospect, we should have heeded Egan earlier, since his notions of philosophic and ironic understanding anticipate this quandary. Philosophic understanding, as in looking for systems, schema, and underlying causes, is well suited to explicitly exploring models and simulations as such (rather than concealing the model in a mythic or romantic wrapper). But because philosophic understanding so enthusiastically embraces the search for cause and effect, there is a strong tendency at this stage to take the model at face value. The ability to step back and question the construction of the model itself truly arrives only with Ironic understanding.

Since questioning models is ultimately such an important skill, we still hope in the future to develop a simulation that facilitates this sort of meta-examination. However, it is clear that the simulation should focus on a familiar domain and be targeted at more advanced (perhaps even college-level) students. Our ecosystem management simulation tried to tackle too much and over-ambitiously

tried to work on two very different levels: the issues surrounding coral reef management efforts, and the art of modeling a real world system. That is simply too much of an analytical load for high school students to handle.

Offering a simulation as an appropriate means of examining a system's function might also leverage Mythic understanding, capturing the users' interest with a dramatic binary opposition between stereotyped forces of good and evil (perhaps polluters and conservationists), then suggesting that this model does not show what's *really* going on and inviting them to dig under the surface of the simulation in search of the truth. In this way, users would find some initial comfort in mythic understanding while engaging in their natural philosophic quest for truth and causality. Similar approaches could easily be applied to history and other subjects where mythic stereotypes are common, but where Ironic understanding might lend a valuable level of sophistication.

Where Do We Go From Here?

The above examples indicate the potential for using learning theory to guide thoughtful and innovative educational design on the Web. When the Web was in its infancy as a medium, trial and error development was appropriate. No one knew what might work, and rapid changes in the technology created a quickly moving target. As the Web has matured, the need for more explicit best practices and metrics for evaluating the quality and success of our projects has become apparent. A face-to-face learning environment allows the effective teacher to respond to subtle cues about student knowledge, interest, and ability. We do not have that luxury online, and instead we must attempt to formalize within the programming of the activity much of the tacit feedback the teacher can draw upon. As we have suggested above, a development process informed by learning theory helps embed the teacher's expertise into an online learning experience that has no two-way communication between real people.

Even as these case studies demonstrate the benefits of explicitly applying learning theory to online activities, they also raise questions. Can rigorous research and evaluation of online learning activities help us refine learning theory as a whole? Can we empirically demonstrate whether these ideas really do improve users' experience, or even their learning (whatever that ultimately is)? Given the present politics of public education in the United States, which emphasizes high stakes testing and demonstrating student mastery of specific standards, we do not serve our clients or their funders well if we continue to offer only impressionistic accounts of the impact of our projects. Such a promise of more objective evaluation might seem hubristic, given how difficult it is to measure the users' experience in the offline world. However, we anticipate that the same technical limitations of online learning that require us to formalize the content and learning methods will also help us to capture and analyze information that will shed light on the user experience.

Furthermore, can we continue to ignore the setting in which online activities are used, or do we have to pay closer attention to where the users are and why they are using the activity? For example, do we need more support for teachers to accompany each activity intended for classroom use? In the case of SEA, Shedd saw teacher support materials as crucial from the outset. We hope to see with further study how support materials affect the effectiveness of the SEA activities. It may be that teachers view electronic activities as by nature self-contained. Given that the Web allows access to all comers, the challenge remains to offer novice users the right entry point without assuming that they can or will use external supporting materials or guidance.

As we have surveyed learning theory, from Kolb to Gardner to Egan, and tried to make sense of our real-world products in their light, it is clear that no one theory can be our single guiding light. It seems more pragmatic to treat the range of learning theory frameworks as a developer's toolbox from which we can pick and choose according to the needs of a particular project. Given the diversity of learners and learning environments, we favor the instrumental view that we should not attempt to impose a single framework on all subject content, learning

goals, use context, and institutional missions and cultures. What works for the context and content of one project may be completely unsuitable for another.

At the end of the day, our thumbnail sketch of learning theory does expose limitations in applying general theories to complex, practical problems. As we discussed above, a strong social constructivist approach to pedagogy that puts a high premium on social interaction and assessing and adjusting to student knowledge may find many current online activities lacking. At the same time, we remain optimistic that some types of online learning experiences open doors to understanding that cannot be offered in any classroom (Prensky 2001). This is not a dismissal of the classroom experience, but a recognition of the ways that computer-aided research tools have dramatically transformed the practice of many research fields, from visualization in the sciences to databases in the humanities. Much of our effort is motivated by the desire to bring these tools within reach of non-experts.

Finally, and most ambitiously, can studying online learning actually advance our understanding of learning, or merely confirm or fail to support existing principles developed for other learning arenas? As the methods and instruments for evaluating online learning mature, we expect online learning to offer a lively test bed for the continuing quest for knowing how we know.

Acknowledgements

The authors wish to thank Minda Borun, Theresa Esterlund, Eric Gyllenhaal, Nancy Ross, and Kris Wetterlund for their insightful comments on earlier drafts of this paper.

References

Bransford, J.D., A. L. Brown, and R.R. Cocking, eds. (2000). *How People Learn: Brain, mind, experience, and school.* Washington, D.C.: National Academy Press.

Davis, J., and H. Gardner. (1993). Open windows, open doors. *Museum News.* January/February 1993.

Egan, K. (1998). *The Educated Mind: How cognitive tools shape our understanding.* Chicago: University of Chicago Press.

Egan, K. (1992). *Imagination in Teaching and Learning: The middle school years.* Chicago: University of Chicago Press.

Egan, K. (1986). *Teaching as Storytelling: An alternative approach to teaching and curriculum in the elementary school.* Chicago: University of Chicago Press.

Gardner, H., (1991). *The Unschooled Mind.* New York: Basic Books.

Gardner, H., (1999). *The Disciplined Mind.* New York: PenguinBooks.

Gyllenhaal, E. D., L. Beaumont, & A. Tyree (2003). Formative evaluation of the On-line Teacher Resources project: Final report. Unpublished manuscript, John G. Shedd Aquarium, Chicago, IL. Available at http://www.sheddaquarium.org/SEA/research/.

Guild, P.B., and S. Garger. (1999). *Marching to Different Drummers,* 2nd edition. Alexandria: Association for Supervision and Curriculum Development.

Hein, G. E. (1998). *Learning in the Museum.* London: Routledge.

Henke, H. (1997). Applying learning theory to computer based training and web-based instruction, last updated April 16, 1997, consulted January 14, 2003,

BEST COPY AVAILABLE

http://scis.nova.edu/~henkeh/story2.htm.

Jonassen, D.H., K.L. Peck, and B.G. Wilson. (1999). *Learning with Technology: A constructivist perspective*. New Jersey: Merrill.

Kolb, D. A. (1984). *Experiential Learning: Experience as the source of learning and development.* New Jersey: Prentice-Hall.

Kolb, D. A., R. E. Boyatzis, and C. Mainemelis. (1999). Experiential learning theory: Previous research and new directions. In R. J. Sternberg and L. F. Zhang (Eds.), *Perspectives on Cognitive, Learning, and Thinking styles.* NJ: Lawrence Erlbaum, 2000.

Prensky, M. (2001). *Digital Game-Based Learning* New York: McGraw-Hill.

Project Zero. (2000). MUSE QUESTs (Questions for Understanding, Exploring, Seeing and Thinking). Cambridge: Harvard University.

Rounds, J. (2002). Storytelling in science exhibits. *The Exhibitionist*, Vol. 21, No. 2 (Fall 2002).

Schaller, D.T., S. Allison-Bunnell, M. Borun, M. Chambers. (2002). How do you like to learn? Comparing User Preferences and Visit Length of Educational Web Sites. In D. Bearman and J. Trant (Eds.), *Museums & the Web 2002: Selected Papers from an International Conference.* Pittsburgh: Archives and Museum Informatics.http://www.archimuse.com/mw2002/papers/schaller/schaller.html

Schank, R. (1992). Goal-Based Scenarios. Chicago: Northwestern University Institute for the Learning Sciences. Technical Report #36. Available at: http://cogprints.soton.ac.uk/documents/disk0/00/00/06/24/cog00000624-00/V11ANSEK.html

Strohkorb, J. (2002). Personal communication.

Turkle, S. (1997). Seeing Through Computers: Education in a Culture of Simulation. American Prospect. Vol. 8, Issue 31. March 1 - April 1 1997. Consulted January 14, 2003.http://www.prospect.org/print/V8/31/turkle-s.html.

Veenema, S. and H. Gardner. (1996). Multimedia and multiple intelligences. *American Prospect*, Vol. 7, Issue 29. November 1 - December 1 1996. Available at: http://www.prospect.org/print/V7/29/veenema-s.html.

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

NOTICE

Reproduction Basis

[X] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

[ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").