The Intersection of Learning Architecture and Instructional Design in e-Learning

Diana L. Wilkinson, AT&T Business Learning Services

Abstract

A sturdy Learning Architecture is necessary to lay the foundation for effective learning in the age of the Internet. Complementary technologies must be integrated into what is potentially so pervasive that it could be said to be a Learning Ecosystem. Not only is the technology of this infrastructure impacted by the decision to knit disparate parts into an integrated whole, but Instructional Design methodology is impacted as well. A Learning Ecosystem capitalizes on reusability, on underlying shared logic and taxonomy, and on convergence of learning and Knowledge Management to support a new model where learning and work are seamlessly and inextricably linked.

TEE 2002
A UNITED ENGINEERING FOUNDATION CONFERENCE
Davos, Switzerland 11-16 August 2002
http://www.coe.gatech.edu/eTEE

I. Introduction

Optimal learning occurs in the simulation of real world, problem-based activities. This happens in a safe environment where errors are expected, and failure deepens learning experience. Optimal learning occurs in environments where:

- Learners are scaffolded as they develop self-efficacy in enabling technologies
- Availability and delivery of instructional resources adapt to learner's needs
- Feedback is continuous
- Scoring is constantly visible to compare accomplishment to one's own previous attempts, the best of one's cohorts, and the total field that has ever been scored
- Access to the underlying knowledge-base has been skillfully crafted and organized for learners
- Cognitive loading is eased until foundation understanding is established, then cognitive dissonance and challenge increased until complexity mirrors the real world
- Pace of learning is controlled by learners
- Peers collaborate, learn from each other, learn to contribute to the knowledge community as they learn to work towards common goals and shared vision
- Mentors coach individuals and teams to remove barriers to understanding, provide guidance to aid in exploration of efficient approaches when students become frustrated, curious, or anxious to validate their understanding
- Challenge is balanced with the needs and abilities of individual students
- Learning experience is perceived as fun.

The challenge of learning and applying that learning is at the core of engineering disciplines. The challenge of technology-based business is to apply engineering solutions to customers' needs. What differentiates both schools and businesses is how well and how efficiently we meet this challenge.

II. Context

We have come to the fork in the road where we can choose to redefine how we learn, how we teach, how we apply, how we solve problems, how we differentiate ourselves and those we represent, and how we contribute to the greater good. Our computing technology and the Internet has evolved to the point that we can leverage and refine the infrastructure to enable authentic learning. We can tap into our collective knowledge reserves both to withdraw and contribute new knowledge, new applications, and new insights. We have begun to experiment with ways to convert inaccessible tacit knowledge into accessible explicit knowledge, and recognize the value of converging these information sources with e-learning. Knowledge management and e-learning provide us with the tools and infrastructure to consciously and dramatically alter our approach.

We learn best by doing. We get our instructional design model backwards when we insist on deluging students with facts, principles, theorems, axioms of both pure and applied science, then expect them to recall and apply this knowledge in practice. We learn best by starting with a realistic problem that needs to be solved and seeking the resources and knowledge relevant to help solve the problem posed. We learn best by making mistakes, having experts tutor and guide us as we improve our solutions until we arrive at optimal ones. We learn best when we accept personal responsibility for our own learning.

We also learn from others through observation and then perfect our newly acquired knowledge via mimicry. We are more efficient learners once we acquire social learning skills. We need to become members of a larger learning community, a network of birds-of-a-feather where we can posit our questions and our insights.

As students we must learn to manage all our resources. We must know how to query for relevant knowledge and discriminate what is valid. We must develop strategies for solving problems. We must have a safe place, a laboratory, where we can experiment, test and make mistakes as we learn. We learn in order to solve problems. We solve problems to improve the human condition and because to do so is intrinsically and/or extrinsically rewarding.

A. Learning Infrastructure

The fork in the road – the enabling technology/the infrastructure – is coming together…but it is not *fait accompli*. One of the architectural problems awaiting solution is the elegant integration of and access to our collective knowledge base. We have to work out the mechanisms of contribution, validation, organization, permission, rights, privileges and payment – but then somehow connect all relevant bodies of knowledge and create simplistic yet intelligent access.

III. e-Learning Strategies

One of Stephen Covey's principles is to "begin with the end in mind." This principle can be applied quite well to the instructional design of e-learning. The premise for a course of learning should be driven by what the student will construct and, what deliverable is to be created that will demonstrate that all requisite skills and knowledge have been mastered. This strategy must be implemented in several areas.

A. Motivation

The design of problem-based learning is not trivial. Problems must be intriguing, relevant and sufficiently challenging to motivate students to want to participate. Not all students will drink willingly from the well. Strategies must be employed to help reluctant students overcome their objections and become active participants. Like shepherds online instructors, facilitators and mentors can expect to spend time locating straggling students and providing them the support, knowledge and incentive to join the learning community.

B. Knowledge Base

Working backwards from the desired learning outcome, the learning delivery system needs to provide access to all relevant resources. These resources can include: a knowledge base, a science, a particular body of knowledge, or a human resource such as a mentor, professor or subject matter expert. The instructional designer is challenged to create a realistic and engaging virtual environment that allows learners to investigate, relate, and apply the knowledge base to resolve the litany of problems involved in constructing desirable epiphanies of understanding.

C. Learning-How-To-Learn

The primary goals of education must be to help students learn how to learn, seek, test, and apply information. Students must learn to build upon what is already known to construct new knowledge, new applications and new solutions. How does e-learning help us ensure more authentic learning is enabled and that we do not simply mirror traditional teaching models in an electronic delivery mode? We must recast our traditional instructional design into constructed new models. Our new models must be performance-based, include problem-solving goals, be contextually relevant and learner-centric. Our new model must focus on developing competencies and critical thinking. Our new models must be sensitive to individual needs and contexts, as well as the dynamics of groups learning as cohorts. We must engineer learning structures to optimize the learner's opportunity to explore, discover and develop personal learning constructs.

D. Problem-based Learning

Goal-oriented problems that are case-based lend themselves to narrative description and simulation. Multiple voices of experts can be evoked to tell relevant stories and direct students to investigate the foundation knowledge necessary to underpin reasonable solutions. The e-learning structure should allow students to peel away the layers of its onionskin as they pursue the construction of their own solutions.

The brave, new world of e-learning will be predicated on our ability to build engaging, realistic scenarios that enable discovery learning. The best designs can be repeated by changing out the specific problem set and/or the resources required for solving the problem within a reusable framework. Fundamental resources may be applicable in multiple contexts. Reusability is key to efficient design, so we must look for opportunities to repurpose content, context, application, and format — the combinations and permutations of which are nearly infinite, and not unduly limiting or stifling to creativity.

IV. Integration of Learning and Work

In the brave new world, learning and work are simultaneous, interlocking activities, as natural and organic as breathing. All information is available in its atomic form as concepts, facts, procedures and actions. Intelligence stems from rules encoded into systems, application of enabling technologies, and critical thinking of people who convert tacit knowledge to explicit information and reverse the process to complete the cycle. More naïve workers extract explicit information from the Knowledge base and convert it into personal, tacit knowledge through repeated practice and experience applying the knowledge in a variety of situations. Tacit knowledge enables skillful performance and wisdom in terms of critical thinking, problem solving, and decision-making.

Learning is a continuous process of solving graduated series of problems resulting in improvement of both performance and performance self-efficacy.

A. Knowledge Management

Knowledge Management is the effort to codify and organize information so it can be viewed as knowledge, and the effort to transfer knowledge to those less knowledgeable. Knowledge management is more than databases and Web portals. It is the total system of discriminating what is useful, codifying it, validating what is useful, making it accessible and retrievable, discriminating what is relevant to a problem, applying knowledge to solve problems, evaluating effect, defining and deriving rules and best practices to contribute back into the knowledge base.

Within any domain of knowledge, there are several tensions or dichotomies of forces that require different management strategies. Some content is within the control of an organization or institution. Some is external, and cannot be directly controlled. Some is universal, while other is local. Some content is stable, while other is dynamic and subject to change. Some knowledge is declarative such as facts or concepts, while other is procedural or rule-based. Validity, reliability and currency of information require overt management.

“Information” is a complex term. Some information is about other information. Some information is related in particular ways to other information. Some are descriptive, illustrative, demonstrative, problem sets, scenarios, directions, applications, or specific to the cause-effect paradigms that relate to prediction and troubleshooting. Knowing these attributes and relationships helps transform information into knowledge. Storing it in a retrievable format helps make at least some of it manageable. Learning to apply knowledge eventually builds wisdom.

B. Instructional Design of e-Learning

Instructional Design methodologies currently fall into two camps. One is the systematic, waterfall approach that adheres to a logical sequence of assessing needs, designing, developing, implementing and evaluating learning solutions, and depends on completing and validating each step before engaging in the next. The contrasting approach depends on the rapid prototyping and iterative refinement of an instructional solution. Both processes have merit, and to some degree, principles from each perspective can be employed in a hybrid solution. The specific balance of which ID approach should predominate should be determined by the situation.

Instruction should augment the relevant body of knowledge in ways that make it accessible, understandable, and relevant to learners. The roadmap for a convergent process could be:

1) Conduct a Needs Assessment.

2) Identify, modify or create relevant competency models for the jobs and skills the correlate with the needs.

3) Build and/or organize relevant Knowledge Base.

   a. Establish or refine underlying content taxonomy.
   b. Craft and/or index libraries of stable and enduring resources to make them accessible.
   c. Create structures to organize the dynamic part of knowledge base; i.e.: asynchronous and synchronous discussion dialogues.
   d. Establish protocol and behavior for contributing to the knowledge base including validation process.
   e. Promote synthesis and data mining of free-form discussions and contributions of both experts and learners.

4) Build Learning Interventions including objectives, sequence of instruction, problem sets around what needs to be known.

   a. Balance strategies for developing skills, knowledge, attitudes and behaviors.
   b. Determine delivery mode or blend of delivery modes.
   c. Leverage, modify or develop competency models to establish benchmark of desirable characteristics and standards.
   d. Build problem sets that match desired competencies. Graduate difficulty level, complexity, and variety of problems.
   e. Develop a scoring rubric for problem-sets.

f. Build scenarios that mirror the real world in which to anchor the problem sets.
g. Associate each scenario and problem set with prerequisite skills and knowledge needed to fully understand and solve the problem.
h. Separate need to know from nice to know.
i. Determine a strategy for weaning learners from spoon-fed access to resources, to learning where to find them in a real world context.
j. Establish an understanding of conventions and navigation of the learning environment.
k. Establish skills necessary for learning-to-learn
    i. Collaboration
    ii. Critical Thinking
    iii. Problem Solving
l. Establish level playing field by screening for prerequisites and providing remediation.

5) Examine course design in terms of adherence to objectives, cohesiveness, graduation of problem sets, comprehensiveness of supportive resources, degree to which each SKAB (Skill, Knowledge, Attitude, and Behavior) is supported.

    a. Identify gaps where more explanation or discovery of underlying knowledge will be necessary to accommodate the range of learners expected to participate.
    b. Create adaptive activities to help learners fill these gaps.
    c. Create feedback mechanisms so learners make adjustments and develop self-efficacy around desired transformations in SKABs.

This process must be must be considered at macro program and curriculum levels as well as micro course and object level. Packaging decisions should be made with regard to sequence of instruction, reusability of components, grading, standards, and independence of content.

1. Assemble objects into courses by selecting scenarios and problem-sets relevant to competency models and performance/learning objectives.

2. Establish an assessment strategy that will satisfy level of mastery required by performance/learning objectives.

3. For each course (within the parameters established by objectives and assessment strategy,) design the overarching premise, the “blend” of independent and collaborative activities and of synchronous and asynchronous learning events, the approach, the metaphor, the challenge, the rallying point, the game...

4. Examine each course in terms of cohesiveness, adherence to objectives, graduation of difficulty of problem sets, comprehensiveness of supportive resources, degree to which each SKAB is supported, and identify gaps where more explanation or discovery of underlying knowledge will be necessary go accommodate the range of learners expected to participate in each offering.

5. Create additional activities to help learners fill residual gaps; create mechanisms for feedback so learners can make adjustments and develop self-efficacy around the focus of learning experience.

V. Learning Ecosystem

The fundamental architectural elements of a comprehensive and cohesive learning ecosystem include (Figure 1):

- Shared, master content taxonomy
- Learning Management System
- Learning Content Management System
- Object Repositories & access to external Knowledge Management & Electronic Performance Support Systems
- Workflow Management & Integration System
- Assessment & Evaluation Engine
- Simulation and Game Engine for Virtual Labs
- Discussion, Collaboration Tools & Web Conferencing
- Mentoring & Support

A. Managing Objects

The foundation of this Learning Ecosystem is built of objects. Objects are built such that “content” of objects is independent of its “container;” that is — to store content in databases and refer to them via Web-enabled index structures commonly built in XML. A genre of commercially available Content Management Systems has emerged to expedite the organization, version-control, ownership permissions, check-in/check-out, and visibility to different audiences of documentation. Other Media Asset Library systems have emerged to serve comparable need to manage original and derivative graphics, photographic images, animation, video, and audio files. Learning Content Management Systems have emerged for the express purpose of

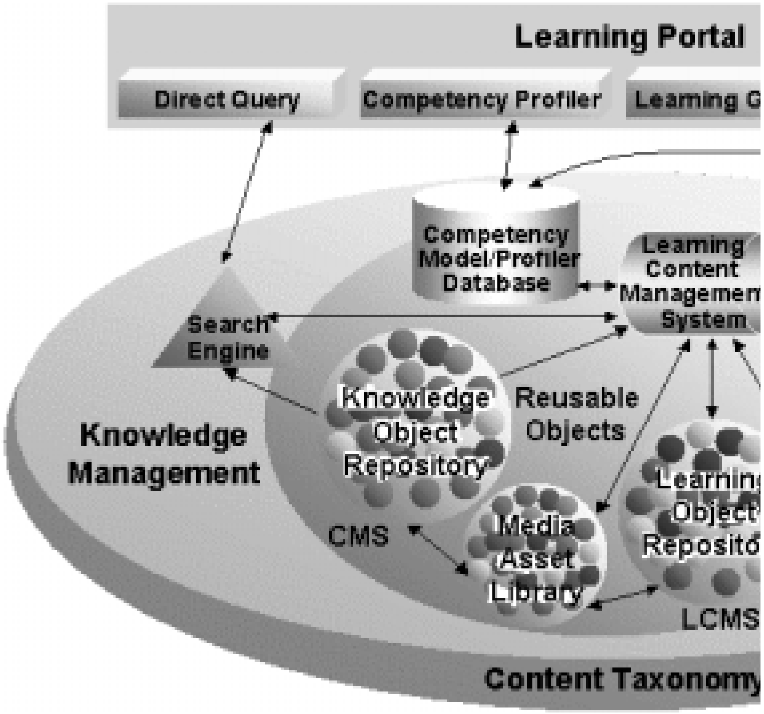

Figure 1. Learning Ecosystem.

managing repositories of Reusable Learning Objects according to SCORM (Shareable Content Object Reference Model) guidelines; the emerging standard being adopted throughout the e-learning industry. These systems require integration around a shared taxonomy.

1) *Reusability:* Decomposing and storing content into objects enables reusability on four different fronts.

   Style: Same "content" object presented with different "containers" differentiated by creative style, framework or "skin."

   Organization: Same object appears in different degree programs, curricula, courses, modules, lessons, etc.

   Context: Same object used as presentation, practice or as reference.

   Output Medium: Same content presented in Web, PDA, or paper formats.

2) *Layers of Reusability:* Objects vary in terms of their potential to be reused, and the contexts in which they can be reused. Candidates for global-reusability must be self-contained units of instruction, free of contextual references, neutral in tone, reasonably stable and validated in the contexts in which they are likely to be reused. Within each specific curriculum and domain of knowledge another layer of reusable objects can also be established. Yet another layer of objects with low probability of reuse will be needed to create the contextually specific elements to create meaningful learning experiences for different audiences concerned with different situations.

3) *Strategies for Maintaining Repository:* To maintain an efficient repository that is not polluted with nearly redundant versions of comparable content, a process for validating reusable content is needed. One approach is systematic. Globally reusable objects are jointly identified, developed, tested and accepted. A minimal set of highly reusable objects will evolve. Another approach is not to control the identification or development of what might be reusable,

but to allow access and evaluation of objects to let the "buyer beware." The chaotic approach will minimize the initial administration, but will inevitably lead to a proliferation of more objects that are not likely to adhere strictly to reusability guidelines. This will make reviewing and selecting existing content a more time-consuming task, and will generally detract from the efficiency of the system. Rather than editing copies of original objects to suit the needs of specific audiences and proliferating redundant objects, the preferred strategy is to use existing objects as is, then complete course assemblies by adding objects of limited potential for reuse in order to establish context.

B. Taxonomies

1) *Content Taxonomy:* Retrieval of content from various repositories is optimized if a common content taxonomy is used. One master taxonomy of the hierarchical topical classifications of the content is needed for the domains of knowledge involved. The taxonomy needs to be dynamically maintained, preferably using a mediated contribution model that allows all content developers to suggest new terms and relationships. Suggestions must be validated by an expert, and then inserted into the taxonomy. Once initialized, the content taxonomy can be used to tie together all the indexing structures of the Learning Management System, Learning Content Management System, and Content and Media Assets Management Systems. The taxonomy can supply consistent, selectable keywords used to describe each objects' metadata. The same taxonomy can be leveraged as the topical classification used to browse content objects. Taxonomy terms and alias/synonym relationships can be defined, expanding its use as a master glossary for the content domain.

The paradox of reusable objects is that although reusability is enhanced by genericising content using neutral tone devoid of humor, and removing contextual references, use of specific contextual grounding and novelty increases both motivation and memory. To optimize and manage the inventory of objects while promoting engaging learning experiences requires blended assembly of both highly reusable and not-so-reusable objects into course deliverables.

2) *Structural Taxonomy:* A structural taxonomy of the content elements and assembly hierarchy facilitates the organization and promotes the reusability of resources (see Table 1).

The assembly hierarchy of this structural taxonomy could be:

- Program
  - Curriculum
    - Course
      - Syllabus/Course Information
      - Topic
        - Problem-Set
          - Environment
            - Backstory
            - Collaboration
          - Problem
            - Scenario
            - Context
            - Requirements
            - Constraints
            - Demonstration
            - Simulation
            - Game
            - Construction
            - Self-test
        - Resource
          - Knowledge
          - Learning Intervention
          - Glossary
        - Test/Self-test
      - Discussion Forums
      - Access to Mentor & Support
      - Assessment
      - Guide

VI. Conclusion

Excellence in delivering effective and efficient e-learning depends on a well-conceived plan to create a comprehensive, integrated infrastructure. This potential can be exploited by employing an instructional design strategy that motivates students and focuses on learning-by-doing. Effectiveness is enhanced by blending problem-based learning with collaborative experience, by blending asynchronous and synchronous learning events, and supporting students individually with mentoring. Efficiencies are gained by designing learning interventions around performance objectives and generalizable competencies. Additional efficiencies are realized by integrating Learning Management Systems, Content and Media Asset Management Systems, Learning Content Management Systems, and engines for building assessments, simulations, games and multi-player laboratory environments.

Content-independence allows for the design elements of "containers" such as templates, "skins," and frameworks to be built once and used many times…freeing content developers to focus on content. Additional efficiencies on the order of Metcalf's Law can be realized as a well-managed foundation layer of globally reusable and highly reusable, domain specific objects evolve, and are assembled into multiple configurations of learning interventions.

Table 1. A Structual Taxonomy.

Object Type	Related Structure	Description
Competency	Job/Degree Model	Descriptions of roles, and skills that apply to each role
Knowledge & Information	Knowledge Base, Content Management System	Facts, Discriminations, Declarations, Concepts, Ideas, Principles, Rules, Procedures, Entities, Actions, Descriptions, Portrayals; Result of deductive or inductive reasoning; Knowledge derived from Information
Syllabus/Course Information	Course	Description of course, expectations, requirements and logistics
Learning	Course (or Search)	Self-contained unit of instruction that provides elaboration of Knowledge, questioning, practice opportunities, feedback
Context	Learning Object or Course (or result of Search)	Establishes the context or situation with which to anchor a learning event
Environment	Learning Object or Course (or Search)	Nice-to-know; Broader than context; establishes the backstory and expanded, peripheral description of context
Scenario	Learning Object or Course (or Search)	Establishes storyline, foundation, circumstances and pre-conditions for a problem or set of problems
Backstory	Learning Object or Course (or Search)	Nice-to-know; establishes background information relating to either scenario or characterization
Problem	Problem-Set, Learning Object, Course (or Search)	Presentation of a question or issue requiring an answer; types include: categorization, interpretation, and design. Feedback is delivered in response to answers
Demonstration	Learning Object or Course (or Search)	Observation of procedure, experiment or cause-and-effect relationships
Simulation	Learning Object or Course (or Search)	Practice opportunity, may take the form of either realism or abstracted fantasy; experience cause-effect relationships
Assessment	Learning Object or Course (or Search)	Collection of question items to be answered, scored and fed-back
Media	Demonstration, Simulation, Environment, Assessment or Course (or Search)	Visual and auditory content including graphics, photographs, animation, video and audio
Guide	Learning Object or Course	Instructions used to aid an instructor/ facilitator; not generally available to students

A. Threats

- Poor models and poorly constructed content will poison learner and institutional acceptance of e-technologies in education.
- Poorly defined and poorly linked taxonomy and searching mechanisms will frustrate rather than enable.
- People of influence may hold on to traditional methods and retard or prevent adoption of e-learning by the critical mass of any discipline.

B. Opportunities

- Creating a meaningful and sound infrastructure including taxonomy and standards for the discipline
- Collaboration across the discipline.
- Exploiting enabling technologies as they emerge.
- Reusability of both "contents" and "containers" increases ability to:
    - Shorten development cycle and reaction time needed to adjust to change
        - Rapid Prototyping
        - Reduction in resources needed for development and testing
        - Rapid Delivery
    - Focus on improving ability to adapt to individual learners' needs for either remediation or acceleration.
    - Focus on sustaining learner motivation by creating gaming contexts, making goals explicit, providing continuously visible scoring, incorporating elements of fantasy where it helps to trigger the imagination and memory, and competition while preserving individual privacy.

C. Achieving Equilibrium

The difficulty is getting to the "tipping point." Once the critical mass of foundation layer objects are in place, momentum will drive increasing efficiencies in the compression of new customized learning offerings. Available resources will be directed towards new work and the pruning and refining of repositories. Complex environments will be costly and time-consuming to build. Strategies that use learners to build this infrastructure provide benefits to learners and the institutions supporting them. Not only will these students learn-to-learn, they will be better prepared to continue to contribute as part of the larger Knowledge Community.

The Learning Ecosystem can be defined within or across institutions to achieve a strategic equilibrium comparable to a non-cooperative game. Each player assumes each other's strategies, then chooses its own. As each player optimizes opportunities, new Nash equilibrium is established. The community will eventually develop practices that will contribute to the greater good. Once arrived at this balance, ongoing energy will be required to sustain the gains and continue to optimize the intersection of learning architecture and instructional design.

Acknowledgments

Thanks to AT&T colleagues in Business Learning Services for validating this paper: David Tai, David O'Leary, Patty Albaugh, Tami Bryan, Claudia Becker, Glenn Schuffenhauer and Kathy Johnstone. Thanks to Wayne Hodgins for his review and advice.

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Author's Biography

Diana Wilkinson is an AT&T Business eLearning Strategist, and was eLearning Manager for AT&T Network Operations and Engineering Training. She has worked as instructional technologist, trainer, course developer, systems analyst, market analyst, account executive, technical sales consultant, data processing operations manager, and programmer. Her recent projects include defining content taxonomy and implementing assessment and evaluation for AT&T's Learning Management System, educating training developers in instructional design for eLearning, integrating accessibility accommodations, and oversight of training administration system facilitating training and knowledge management support of managers preparing for alternate assignments in advent of business emergencies.

Ms. Wilkinson has completed all but dissertation for a Ph.D. in Educational Technology at University of Kansas, an MBA from Webster University, and BA in Mathematics from William Jewell College. Her interests include: development of unified theory for eLearning, games and simulations, intelligent tutors, interface designs, assessment and evaluation, mentoring networks, optimizing "Flow" and learner experience.