LEARNING OBJECTS IN DIFFERENT PEDAGOGICAL PARADIGMS

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Abstract

Based on the review of several pedagogical paradigms, this paper attempts to

- clarify the concepts of learning resources and learning objects,
- propose a way forward in the use of learning resources in different pedagogical paradigms in a large scale collaborative environment, and
- expose characteristics required in different learning objects to match the requirements of different pedagogical paradigms.

Keywords

Learning object, learning resource, pedagogical designs, learning technology standards

Introduction

The notion of small, reusable units or components in a learning environment has a lot of appeal to both educators and designers of virtual learning environments. (Reigeluth, 1996) suggest that teachers gaining access to instructional materials for the first time, will often break the materials down into their constituent parts. Teachers then reassemble or substitute (some of) these parts in ways that support their individual instructional goals. Reusable or replaceable instructional components, or learning resources and learning objects, may provide benefits by simplifying disassembly or replacement/substitution, potentially increasing the speed and efficiency of instructional development. This paper walks through several pedagogical paradigms and attempts to identify components that may be packaged for reuse in either similar or different pedagogical designs.

The term "learning object" is used very broadly in this paper. For a more detailed analysis of terminology relating to this notion, see (Ip, Morrison, & Currie, Accepted 2001; Wiley, Gibbons, & Recker, 2000). It is sufficient to note here that learning object includes the software mechanism to render (and support the associated user interface for interactivity) the content and enable access. In this paper, our notion of learning objects is limited to those that are used directly by a learner. The mechanism to enable multiple learning objects to co-exist and interoperate with each other (learning architecture issues) is not considered here. In addition, while lesson plans and other enabling resources such as Educational Modeling Language (EML, 2001) or the manifest file defined within IMS content packaging specification (Young & Riley, 2000) are educational material, we exclude them from the scope of the present analysis.

Pedagogical paradigms selected for this paper do not form an exhaustive list of contemporary pedagogical frameworks. Rather, they have been selected to provide an indication of the extent of the technical issues that we must face as we attempt to understand the issues of reusing learning resources and learning objects in virtual learning environment design. This work may inform the formulation of specifications such as IMS content packaging (IMS, 2001), ADL's Shared Content Object Reference Model (ADL, 2001) and IEEE Learning Object Metadata (IEEE, 2001). Within the Australian context, this work may provide further understanding to guide the design of sharable, interoperable and reusable content for projects such as Schools Online Curriculum Content Initiative (SOCCI).

Tutorial, Drill and Practice

At one end is "drill and practice". At the other end, a tutorial environment provides a mechanism for presenting a problem to the online learners and provides feedback depending on the answer. When appropriately designed, the feedback mechanism can support a pre-emptive version of the Laurillard conversation model of higher learning (Laurillard, 1998)

A reusable unit may be an item (consisting, say, of the stem which is the question and responses, feedback and scoring information). The IMS Question and Testing Interoperability (IMS QTI) specification (Smythe & Shepherd, 2001) is a good candidate framework for encoding learning resources for reuse in this paradigm. The specification is designed to support question and test interoperability between different authors, publishers and other corresponding content developers.

Learning engine (Fritze & Ip, 1998; Fritze & McTigue, 1997) is a rich environment for drill and practice that allows learners to interact with input/output and a visualization device. The learner may respond to an item by drawing on a graphing device in addition to selecting any pre-drawn graphs. The reusable component is both the resource determining the graph and the software component acting as the input/output and visualization device. Another software component, Text Analyzing Object (TAO) (Kennedy, Ip, Adams, & Eizenberg, 1999; Kennedy, Ip, Eizenberg, & Adams, 1998) is also a reusable unit which has special software coupled with the resource.

Case Study Method

A teaching case is a story describing, or based on, actual events, justifying careful study and analysis by students. In other words, a teaching case is a story about the “real world” told with a definite teaching purpose in mind. A teaching case is a way of bringing the real world into a classroom so that students can “practice” on actual or realistic problems under the guidance of their teacher. Case teaching, unlike conventional lecturing, is discussion-based and experiential. The teaching case replaces the lecture as the vehicle for learning, and the case becomes the basis for discussion, exchange of ideas, knowledge and experience among participants. (Lynn, 1996; Rangan, 1995)

The case study method has been practiced in the United States for many decades. It was made famous, first, by Harvard University's Business School and, later, by Harvard University's John F. Kennedy School of Government. Now cases are widely available from these two schools as well as via the World Wide Web from other sources. Obviously, the learning resources are the teaching cases together with all the discussion questions. Additional educational materials supporting the case study method normally include teaching guides associated with the cases. Proper metadata tagging will promote the discovery of appropriate cases for specific learning situation and themes.

Goal-based learning

Goal-based scenarios (GBS) are essentially simulations in which there is a problem to solve, or a mission to complete. They require learners to assume the main role in the solving of the problem or the pursuit of their mission (Schank, 1997; Schank, 1990). Hence, goals in this context refer to the successful completion of the task at hand, and not the achievement of grades. Scaffolding support is available to the learners in the form of stories (commonly presented as video clips with a talking head) as told by an actor in the scenario (see (Schank & Cleary, 1995)). A GBS serves both, to motivate learners and also provide them with the opportunity to learn by doing, by making mistakes, and receiving feedback.

The description of the scenario is obviously a resource that may be reused in other paradigm such as the case study method. The major challenge in creating GBS is the just-in-time requirement of providing the learners with appropriate stories (as text or as video clips with the appropriate context). The embedding of context within video clips obviously will restrict the potential of reuse of the clip in a different context. For stories in the form of text, we will require sophisticated tagging in order for the goal-based learning system to locate relevant learning resource efficiently.

Learning by designing

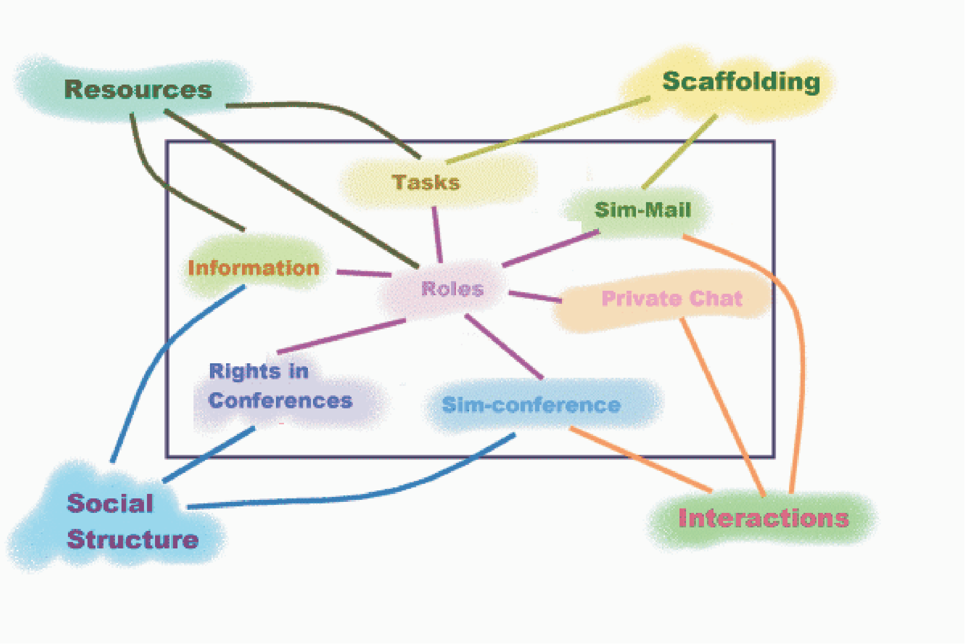
This is an educational context in which the core learning activity is the design of an artifact. Designing as a means for acquiring content knowledge is commonly used in practice-based disciplines such as engineering and architecture (Newstetter, 2000; Hmelo, Holton, & Kolodner, 2000). The obvious benefit of a design task is its inherent situatedness or authenticity. In design-based learning activities, students' understanding is "enacted" through the physical process of conceptualizing and producing something.

When students are creating an artifact (digital or otherwise), the learning architecture needs to be able to track the artifacts by automatically applying either embedded or detached metadata for the artifacts. Tanimoto proposed a framework for Distributed Transcripts for Online Learning (Tanimoto, 2001) based on artifacts created during the learning process.

Learning objects created by the learners may still have reuse values such as acting as examples for other groups of students, or as transcript of the learning process.

Web-based role-play simulation

Role-play simulations are learning situations in which learners take on the role-profiles of specific characters in a contrived educational game. (Linser, Naidu, & Ip, 1999). As a result of playing out roles in a role play simulation, learners are expected to acquire the intended learning outcomes as well as make learning enjoyable. While the underlying belief of web-based role play simulation is similar to goal-based scenario, it differs in both the dynamic nature of the goals and the mechanism supporting learning.



Among other things, stories or cases are used to create an authenticate scenarios. However, other resources, including real time news, play an important part in enriching the learning experience. The use of resources not originally created for educational consumption is an interesting issue. (Ip, Morrison, Currie, & Mason, 2000) The learning architecture needs to support interchange of information among the learners, especially bi-directional communication capability, raising the bar for the technology to provide collaborative and co-operative learning.

Distributed problem-based learning

Problem-based learning (PBL) is an instructional approach that exemplifies authentic learning and emphasizes solving problems in rich contexts. It uses an instructional problem as the principle vehicle. The analysis and study of this problem comprises several phases that are spread over periods of group work and individual study (Barrows & Tamblyn, 1980; Schmidt, 1983; Evensen & Hmelo, 2000). A typical environment (e.g. Liu, Williams, & Pedersen, 1999) based on PDL will:

(1) Situate the problem in a rich context and allowing learners to engage in scientific inquiries as experts do;
(2) Present the problem with its complexity, yet providing tools to support students in working with complexity;
(3) Provide information in multimedia formats to allow dynamic and interactive presentations that address different learning styles and student needs;
(4) Provide experts' guidance from multiple perspectives to facilitate knowledge acquisition and transfer; and
(5) Emphasize the interrelated nature of knowledge.

Distributed problem-based learning refers to the use of this strategy in a networked computer-supported collaborative environment where face-to-face communication among participants is not essential.

Problems are resources with specific learning objectives. However, the problem would need to be richly linked to other resources in order to create the rich context required to create the complexity and authenticity for learners if they are to fully engage in this paradigm. Like web-based role-play simulation, this paradigm requires collaboration support from learning architecture. Unlike web-based role play simulation, most of the current online generic conference features found in LMS will meet the need of this pedagogical design.

Critical incident-based computer supported learning

There has been a growing interest in building learning environments focussing on supporting groups of learners engaged in reflection on critical incidents occurring in their workplace (Wilson, 1996). Reports of a group of maintenance technicians sharing knowledge while conversing during an afternoon tea-break supports the effectiveness of sharing of experiences. During these casual conversations, these technicians shared their "war stories" about how they solved problems daily. In the casual and friendly environment of the afternoon tea, the third-person experience, as told in first person, quickly transformed into the repertoire of the listeners. This gives rise to the premise that the storyteller has a lot of potential as a support for learning.

A critical incident (from the workplace) presents a learner with a learning opportunity to reflect and act on. Learners can do this by keeping learning logs which are a record of the learning opportunities presented. The critical attribute of the learning log is that it concentrates on the process of learning. It is not a diary of events nor is it a record of work undertaken, rather it is a personal record of the occasions when learning occurred or could have occurred. The learning log also relates prior learning to current practice and is retrospective and reactive in action.

The learning architecture needs to support distributed management of learning logs. Most computer supported collaboration environment would be sufficient to support this type of learning.

The resource created during this process, i.e. the learning log, has some reuse value in the form of experiences of how other workers approach their learning in similar situation.

Rule-based simulation

Rule-based computer simulations (RBS) are educational programs modelling real systems. The learner's basic actions are changing the values of some input variables and observing the resulting changes in values of output variables. (de Jong, Swaak, Scott, & Brough, 1995) Rule-based systems are either conceptual or operational models (van Berkum & de Jong, 1991) Conceptual models contain principles, concepts, and facts related to the (class of) system(s) being simulated. Operational models include sequences of cognitive and/or non-cognitive operations (procedures) that can be applied to the (class of) simulated system(s). Examples of conceptual models can be found in economics (Shute & Glaser, 1990) or in physics (e.g. electrical circuits) (White & Frederiksen, 1989; White & Frederiksen, 1990) Operational models can be further divided into models where timing of actions is not relevant (e.g. troubleshooting of avionics, (Lesgold, Lajoie, Bunzo, & Eggan, 1992), or troubleshooting of complex devices(Towne et al., 1990)), or where timing is critical (e.g. radar control, (Munro, Fehling, & Towne, 1985), flight simulation). In many cases, real operational proficiency includes knowledge of an associated conceptual model (de Jong et al., 1995; Kieras & Bovair, 1984). For example, operational knowledge on fault diagnosis can be related to conceptual knowledge of the device that is to be diagnosed. The value of RBS is the opportunity provided to the learners to try out different scenario in a safe and economical environment.

Microworlds, or computer simulations of restricted environments are a form of rule-based computer simulation. They are an intuitively appealing way to promote discovery and exploratory learning. (Papert, 1980) called computer supported microworlds "incubators for knowledge" when he described the potential of computer aided learning to encourage exploration and thus self-education by children. His educational philosophies stem from Piaget's work on learning which, simplistically, state that much of children's learning occurs without being taught: children construct their skills and understanding from seeds of knowledge.

Creation of digital microworld for simulation and learning may be one of the most challenging and creative aspects of designing learning objects and learning architecture. Learning objects in this paradigm will be active software component (agent) interacting with other components in the microworld. Efforts in creating interoperability components for use in this environment include (Ip & Canale, 1996); (AgentSheets,) (E-slate, 2000) and (ESCOT, 2001)

Exploratory Learning

Exploratory uses of instructional technology allow students to direct their own learning. Through the process of discovery, or guided discovery, the student learns facts, concepts, and procedures. (Department of Education, 1993) The pedagogical underpinning is closely related to rule-based simulation. The difference is the focus of the exploration. In rule-based simulation, the exploration is a simulator and the challenge is the creation of the simulation. For exploratory learning, the focus is on information or resources and the challenge is effective resource discovery while protecting minors from indecent or otherwise inappropriate material.

In traditional learning environment, the information available to learners (e.g. children in school) have been carefully selected, edited or reworked to meet both the "duty of care" and the learning profiles of the learners. (The school library plays an important role in the selection process.)

However, with the advent of the communication network, resources, including those not originally intended for educational consumption or even young learners, may be available to learners during exploratory learning. (Ip et al., 2000; Ip & Naidu, 2001) highlighted the need for a rethinking of the issues of availability of material for educational use.

Cognitive tool

(Reeves, 1999) suggests two major approaches to using interactive learning systems and programs in education.

First, people can learn “from” interactive learning systems and programs, and second, they can learn “with” interactive learning tools. Learning “from” interactive learning systems is often referred to in terms such as computer-based instruction or integrated learning systems (ILS). Learning “with” interactive software programs, on the other hand, is referred to in terms such as cognitive tools (Lajoie, 1993); (Jonassen & Reeves, 1996) and constructivist learning environments. With the use of such "cognitive tools", learners can enter an intellectual partnership with the computer in order to access and interpret information, and organize personal knowledge. Computer-based cognitive tools have been intentionally adapted or developed to function as intellectual partners to enable and facilitate critical thinking and higher order learning.

Typical cognitive tools include databases, spreadsheets, semantic networks, expert systems, concept maps, communication software such as teleconferencing programs, on-line collaborative knowledge construction environments, multimedia/ hypermedia construction software, and computer programming languages.

Learning objects need to be software able to support learning. TAO (Kennedy et al., 1999; Kennedy et al., 1998) doubles as a cognitive tool as well.

Resource-based Learning Environment

Resource-based Learning Environment (RBLE) emphasizes a transformation of meaning through learner-centered, system-facilitated action. RBLEs support and extend efforts to know, understand, and generate, that is, to reflect, construct, solve problems, and integrate new information for one’s own purposes (e.g., curiosity, dissonance) as well as for others’ purposes (e.g., research topic, gain varied perspectives on an issue, solve an assigned problem) (Land & Hannafin, 1996). They provide not only comprehensive collections of highly indexed data, information, and search engines, they help learners to reason, reflect, and assess the veracity of the systems’ contents.

Traditionally, special collection of resources in library will provide the starting basic of RBLS. Obviously, indexing and providing efficient discovery of learning resource are of prime importance in this environment.

Summary

Pedagogical Design	**Nature of the resources**	**Need special rendering software**	**Resources are specifically designed for educational use**
Tutorial, Drill and Practice	Test or drill items, (may be structured to meet interoperability standards such as IMS QTI)	Yes – directly or indirectly Some learning objects may have embedded content and some may not.	Yes
Case Study Method	Teaching cases	No - cases are normally hardcopy but online cases can include video – but hard-wired to the learning scenario (see GBL)	Yes
Goal-based learning	Stories, or video clips, provided mainly 'on-demand'	No	Yes
Learning by designing	The requirement for an artifact	No	Yes
Web-based role-play simulation	A scenario & associated design of the role play simulation resources	No, but the environment itself may be a specialist engine (Ip & Linser, 1999)	Scenario etc: yes Resources: no
Distributed problem-based learning	Problem for solving during the learning	No	Yes
Critical incident-based computer supported learning	Opportunities for learning - incidence	No	No
Rule-based simulation	Embedded in the software	Yes, most component-based approaches to creating rule-based simulation will have embedded content in the components which roughly map to learning objects in this paper	Yes
Cognitive tool	Structured content to work with some tools, generic tools may not need any content	N/A	N/A
Resource-based Learning Environment	Resources	Search tool and resource discovery mechanism, e.g. in the form of support from subject gateways	No

Table 1: Use of Resources in Different Pedagogical Design

Implication For Understanding Learning Objects And Learning Resources

We use a diverse range of resources in our practice of teaching and learning. In summary there are:

- specifically written reading material (case method, problems in problem-based learning) - learning resources
- reading resources originally created for other purposes (web-based role play simulation, exploratory learning, resource-based learning) - we refer to these type of resources as NEF resources, see (Ip et al., 2000; Ip & Naidu, 2001).
- multimedia resources conveying an authentic situation and a sense of authority (video clips in goal base learning) - multimedia learning resources requiring generic rendering software (such as QuickTime player)
- structured resource designed to be used in an interactive way (items in tutorial, drill and practice) - structured learning resources requiring the service of specialised learning objects. Some learning objects may have the content embedded in a way that makes further separation of the rendering mechanism from the content impossible and
- specialised software agent with embedded content and context (as in component-based rule-based simulation).

We also use a diverse range of software components and/or systems such as

- cognitive tools,
- collaboration systems to support the generic communication,
- specialised system as in web-based role play simulation, and
- rule-based simulation.

Some of these software components work with structured content (TAO as a cognitive tool and learning engine).

In other words, learning resources (both text and multimedia) include both resources specifically created, selected and edited for learners and NEF resources drawn from other sources.

The former resource may not be structured. These resources can be rendered by generic device (such as text viewer or web browser). There are structured learning resources (such as those created conforming to IMS QTI specification (Smythe & Shepherd, 2001)) which need to be rendered by special matching software in order to be used effectively in an educational context.

Some educational software render several structured educational resources of the same type, other will have the educational content embedded (such as the Java Applets submitted to Educational Object Economy (EOE, 2000)).

In object-oriented software design, a software component has defined roles, interfaces with other components, internal or public attributes and public actions (or methods). These features allow components to work together as a whole system. A learning object may have

- Attributes in the form of the resources that go with the object. For example in the case of question and testing, the rendering software is a Q&T object and the items, defined in IMS QTI, as the attributes to this object
- Behaviour in order to allow other learning objects to interact e.g. to provide rule-based simulation
- Interface for activation.

The creation of the learning object (as standalone software or software component) and the content (as attribute) demands different skills. The former calls for expertise in software development and the latter requires subject matter expertise. In looking at each pedagogical paradigm, we can see a separation of the content elements (text, graphics, referenced sources, etc), from their means of packaging/assembly and the means of supporting interactivity (with students, CMS and LMS) and open access. The separation of the content data, from the packaging and communication (access and interaction) is important. Current emerging technologies, such as XML/Data Binding and XML transformation languages (XSLT), are beginning to support it. This proper clarification of roles of the developer (software development, pedagogical design and subject matter creation) (Ip, 1997) will be a welcome approach to efficiently create engaging educational courseware.

The embracing of the 'digital agenda' by an individual educational institution is an expensive proposition and it is important to leverage as far as possible through re-purposing and re-use the learning resources. It is also important where means of capturing sound pedagogies into a technical vehicle are possible that these too foster re-purposing and re-use. Learning objects, being an encapsulation of both the rendering software and the subject matter content, represents a potential unit of multiple deployments in different situations. However, there is a difference between learning objects and learning resources, the latter implies content, the former implies addition of the (technical) vehicle to afford encapsulation, support interactivity and manage access. (Here learning resource is naively defined as just the resource) Understanding of this difference is a first step towards a re-use framework to control the cost of the digital agenda.

References:

ADL. (2001). *Advanced Distributed Learning Network Website*. [Online] Available: http://www.adlnet.org/ [26th September 2001]

AgentSheets. *Agent Sheet Website* .[Online] Available: http://www.agentsheets.com [26th September 2001]

Barrows, H. S., & Tamblyn, R. (1980). *Problem-based learning: An approach to medical education.* New York: Springer.

de Jong, T., Swaak, J., Scott, D. M., & Brough, J. (1995). *The use of simulations for training engineers in the process industry.* Paper presented at the Conference of the European Association for Research on Learning and Instruction, Nijmegen, The Netherlands.

Department of Education, U. (1993). *Technologies for Exploratory Learning* . [Online] Available: http://www.ed.gov/pubs/EdReformStudies/TechReforms/chap2c.html [26th September 2001]

EML. (2001). *Educational Modelling Language Project Website* [Online] Available: http://eml.ou.nl/introduction/ [26th September 2001]

EOE. (2000). *Educational objects economy website* [Online] Available: http://www.eoe.org/eoe.htm.

ESCOT. (2001). *Education Software Components of Tomorrow Website* [Online] Available: http://web.escot.org/ [26th September 2001]

E-slate. (2000). *E-slate project website* [Online] Available: http://E-Slate.cti.gr [26th September 2001]

Evensen, D. H., & Hmelo, C. E. (2000). *Problem-based learning: A research perspective on learning interactions*. Mawah, NJ: Lawrence Erlbaum Assocites, Inc., Publishers.

Fritze, P., & Ip, A. (1998). *Learning Engines - a functional object model for developing learning resources for the Web.* Paper presented at the ED_MEDIA & ED-TELECOM 98 Conference, Freiburg.

Fritze, P., & McTigue, P. (1997). *Learning Engines - a Framework for the Creation of Interactive Learning Components on the Web* [Online] Available: http://www.curtin.edu.au/conference/ascilite97/papers/Fritze/Fritze.html [26th September 2001]

Hmelo, C. E., Holton, D. L., & Kolodner, J. L. (2000). Designing to learn about complex tasks. *The Journal of the Learning Sciences, 9*(3), 243-246.

IEEE. (2001). *IEEE LTSC Website* [Online] Available: http://ltsc.ieee.org [26th September 2001]

IMS. (2001). *IMS Global Learning Consortium, Inc. Website* [Online] Available: http://www.imsproject.org [26th September 2001]

Ip, A. (1997). Higher Education & Web-based Learning: Five Challengers and a Proposed Solution (Vol. Feature of the week at Education Object Economy,).[Online] Available: http://www.eoe.org/FMPro?-db=Objects.fp3&-token=libraryPapers&-format=/library/paperdetail.htm&-recid=35188&-lay=all&-Find [26th September 2001]

Ip, A., & Canale, R. (1996). *A model for authoring virtual experiments in web-based courses.* Paper presented at the ASCILITE 96.

Ip, A., & Linser, R. (1999). *Web-based Simulation Generator: Empowering Teaching and Learning Media in Political Science* [Online] Available: http://www.roleplaysim.org/papers/rpsg.htm [26th September 2001]

Ip, A., Morrison, I., & Currie, M. (Accepted 2001). *What is a learning object, technically?* Paper presented at the WebNet 2001.

Ip, A., Morrison, I., Currie, M., & Mason, J. (2000). *Managing Online Resources for Teaching and Learning.* Paper presented at the AusWeb2K, the Six Australian World Wide Web Conference.

Ip, A., & Naidu, S. (2001). Reuse of Web-Based Resources in Technology-Enhanced Student-Centered Learning Environments. *Campus Wide Information Systems*.

Jonassen, D. H., & Reeves, T. C. (1996). Learning with technology: Using computers as cognitive tools. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 693-719). New York: Macmillan.

Kennedy, D. M., Ip, A., Adams, C., & Eizenberg, N. (1999). *Developing Generic Interactive Learning Tools to Engage Students: The Text Analysis Object for Web and CD-ROM.* Paper presented at the EdMedia99.

Kennedy, D. M., Ip, A., Eizenberg, N., & Adams, C. (1998). *The Text Analysis Object (TAO): Engaging students in active learning on the web.* Paper presented at the Australian Society for Computers in Learning in Tertiary Education Annual Conference, NSW Australia.

Kieras, D. E., & Bovair, S. (1984). The role of a mental model in learning to operate a device. *Cognitive Science, 8*, 255-273.

Lajoie, S. P. (1993). Computer environments as cognitive tools for enhancing learning. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as Cognitive Tools* (pp. 261-288). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Laurillard, D. (1998). *Rethinking university teaching: A framework for the effective use of educational technology*. London: Routledge.

Lesgold, A., Lajoie, S., Bunzo, M., & Eggan, G. (1992). SHERLOCK: A coached practice environment for an electronics troubleshooting job. In J. H. L. R. W. Chabay (Ed.), *Computer-assisted instruction and intelligent tutoring systems: Shared goals and complementary approaches* (pp. 201-239). Hillsdale, NJ: Erlbaum.

Liu, M., Williams, D., & Pedersen, S. (1999, June 19-24, 1999). *The Design and Development of A Hypermedia-Supported Problem-Based Learning Environment.* Paper presented at the Ed-Media 99, Seattle, Washington.

Lynn, L. E. (1996). *What is the Case Method? A Guide and Casebook*. Japan: the Foundation for Advanced Studies on International Development.

Munro, A., Fehling, M. R., & Towne, D. M. (1985). Instruction intrusiveness in dynamic simulation training. *Journal of Computer-Based Instruction, 2*, 50-53.

Newstetter, W. C. (2000). Guest editor's introduction. *The Journal of the Learning Sciences, 9*(3), 247-298.

Papert. (1980). *Mindstorms -- Children, Computers, and Powerful Ideas.* Brighton: Harvester Press.

Rangan, K. (1995). *Choreographing a Case Class* [Online] Available: http://www.hbsp.harvard.edu/products/cases/casemethod/rangan.pdf [26th September 2001]

Reeves, T. C. (1999, June 19-24, 1999). *A Research Agenda for Interactive Learning in the New Millennium.* Paper presented at the Ed-Media 99, Seattle, Washington, USA.

Reigeluth, C. M. (1996). A new paradigm of ISD? *Educational Technology*(May-June), 13-20..

Schank. (1997). *Virtual Learning: A Revolutionary Approach to Building a Highly Skilled Workforce.* New York: McGraw-Hill.

Schank, R. C. (1990). *Tell Me A Story*. Evanston, Illinois: Northwestern University Press.

Schank, R. C., & Cleary, C. (1995). *Engines for Education,*. Hillsdale, NJ:: Lawrence Erlbaum Associates Publishers,.

Schmidt, H. G. (1983). Foundations of Problem-based learning. Sme explantory notes. *Medical Education, 27*, 11-16.

Shute, V. J., & Glaser, R. (1990). A large-scale evaluation of an intelligent discovery world: Smithtown. *Interactive Learning Environments, 1*, 51-77.

Smythe, C., & Shepherd, E. (2001). *IMS Question & Test Interoperability: ASI Information Model Specification (version1.1)* [Online] Available: http://www.imsproject.org/question/qtinfo03.html [26th September 2001]

Tanimoto, S. L. (2001). Distributed Transcripts for Online Learning: Design Issues. *Journal of Interactive Media in Education*.

Towne, D. M., Munro, A., Pizzini, Q., Surmon, D., Coller, L., & Wogulis, J. (1990). Model-building tools for simulation-based training. *Interactive Learning Environments, 1*, 33-50.

van Berkum, J. J. A., & de Jong, T. (1991). Instructional environments for simulations. *Education & Computing, 6*, 305-358.

White, B. Y., & Frederiksen, J. R. (1989). Causal models as intelligent learning environments for science and engineering education. *Applied Artificial Intelligence, 3*(2-3), 83-106.

White, B. Y., & Frederiksen, J. R. (1990). Causal model progressions as a foundation for intelligent learning environments. *Artificial Intelligence, 42*, 99-157.

Wiley, Gibbons, & Recker. (2000). *A reformulation of the issue of learning object granularity and its implications for the design of learning objects* [Online] Available: http://reusability.org/granularity.pdf [26th September 2001]

Wilson, B. G. E. (1996). *Constructivist learning environments: Case studies in instructional design.* Englewood Cliffs , New Jersey: Educational Technology Publications.

Young, B., & Riley, K. (2000). *IMS Content Packaging Information Model (v1.1)*: IMS.