LEARNING OBJECTS IN DIFFERENT PEDAGOGICAL PARADIGMS

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Abstract

Based on the review of several pedagogical paradigms, this paper attempts to (i) clarify the concepts of learning resources and learning objects, (ii) propose a way forward in the use of learning resources in different pedagogical paradigms in a large scale collaborative environment, and (iii) 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 and Nelson (1997) suggest that when teachers first gain access to instructional materials, they often break the materials down into their constituent parts. Teachers then reassemble or substitute for (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 which 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, 2001; Wiley, Gibbons & Recker, 2000). Suffice it to note here that learning objects include 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 coexist and interoperate with each other (learning architecture issues) is not considered here. In addition, while lesson plans and other enabling resources, such as the Educational Modelling Language (EML, 2001) or the manifest file defined within the IMS content packaging specification (Young & Riley, 2000), are educational material, we also exclude them as learning objects in our analysis here.

Pedagogical paradigms selected here 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 need to be faced 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), Advanced Distributed Learning (ADL) Network 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 shareable, interoperable and reusable content for projects such as “Schools Online Curriculum Content Initiative (SOCCI)”.

We will first provide an overview of the main features of, and software/systems requirements of, pedagogic approaches in use, then we will summarise these with reference to possible technical implementation requirements.

Tutorial, Drill and Practice

At one end is the rote of “drill and practice” and at the other end, a tutorial environment which 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 engines (Fritze & Ip, 1998; Fritze & McTigue, 1997) are a rich environment for drill and practice by allowing learners to interact with input/output and a visualisation 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 which determines the graph and the software component which acts as the input/output and visualisation device. Another software component, Text Analysis 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, that justifies 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 resolve, or a mission to complete. They require learners to assume the main role in the resolution 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 to the learners is available 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 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 resources efficiently.

Learning by Designing

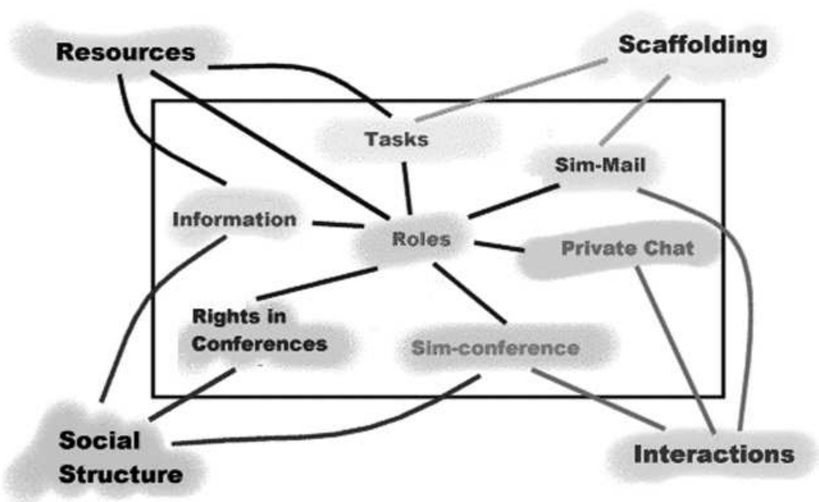
This is an educational context in which the core learning activity is the design of an artefact. Designing as a means for acquiring content knowledge is commonly used in practice-based disciplines such as engineering and architecture (Newstetter, 2000; Hmelo, Holton & Kolodner, 2000). The obvious benefit 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 artefact (digital or otherwise), the learning architecture needs to be able to track the artefacts by automatically applying either embedded or detached metadata for the artefacts. Tanimoto (2001) proposed a framework for Distributed Transcripts for Online Learning which is based on artefacts 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 as well as the mechanism in 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 which are created originally not 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 cooperative learning.

Distributed Problem-based Learning

Problem-based learning (PBL) is an instructional approach that exemplifies authentic learning and emphasises 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) that is based on PBL will:

1. Situate the problem in a rich context and allow learners to engage in scientific inquiries as experts do;
2. Present the problem with its complexity, yet provide 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. Emphasise 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 for it to have the complexity and authenticity for learners 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 growing interest in building learning environments that focus on supporting groups of learners engaged in reflection on critical incidents from their workplace (Wilson, 1996). Reports of knowledge sharing during the afternoon tea-break conversation of a group of maintenance technicians, supports the effectiveness of sharing of experiences. During these informal causal conversations, these technicians shared their "war stories" about how they solved problems daily. In the casual and friendly environment over 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 there is much potential for the storyteller for supporting learning.

A critical incident (from the workplace) presents a learner with a learning opportunity to reflect in and on action. Learners can do this by keeping learning logs which is a record of 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 that model real systems. The learner's basic actions are to change the values of some input variables and observe the resulting changes in the values of output variables (de Jong & Joolingen, 1996). 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; 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 trouble-shooting of complex devices, (Towne et. al., 1990), or where timing is critical e.g., radar control, (Munro, Fehling, & Towne, 1985), or flight simulation. In many cases, real operational proficiency includes knowledge of an associated conceptual model (de Jong, Swaak, Scott & Brough, 1995, August; 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) which interacts with other components in the microworld to model the environment. Efforts in creating interoperability components for use in this environment include (Ip & Canale, 1996; AgentSheets, Online; 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 USA, 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 environments, 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 may be available to learners during exploratory learning. Ip et al. (2000) and Ip and Naidu (2001) highlighted the need to rethink the issues of availability of materials 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 organise 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, communications 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 which 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) emphasises a transformation of meaning through learner-centred, 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 collections of resources in libraries will provide the starting basic of RBLEs. 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

Pedagogical Design	Nature of the resources	Need special rendering software	Resources are specifically designed for educational use
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 up 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 in order to convey authentic situation and a sense of authority (video clips in goal base learning) - multimedia learning resources requiring generic software to render (such as QuickTime player)
- structured resources 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 further separation of the rendering mechanism and content is impossible and
- specialised software agents 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 renders 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 role, interface, attributes and actions in order for different software objects 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 a rendering to provide selection in question and testing, the rendering software is the Q&T object and the items defined in IMS QTI is the acceptable attribute to this object
- Behaviour in order to allow other learning object to interact e.g. for provide rule-based simulation
- Interface for activation.

The creation of the learning object (as software supporting assembly, interactivity and behaviour) and the content (as attribute) demand 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), the means of packaging/assembly of these 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 an important one that current emerging technologies such as XML/DataBinding and XML transformation languages (XSLT) are beginning to enable. 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.

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