Abstract

Singh, Harmanpreet. Developing an e-learning Model for an Industrial Enterprise.

(Under the guidance of Dr. Laurie Ann Williams)

Until recently, not much effort has been spent on developing e-learning courses with the intention of reuse. Generally, e-learning content developers have not used specifications or standards. As a result, every time a course needed to be developed, the course was started from scratch, even if the contents were quite similar to previously developed courses. This obviously wastes much time and effort and is inherently an inefficient technique. By the introduction of a fairly new concept of learning objects, developing and organizing learning/instructional content into small modules has enabled more organized development. Learning objects are logically demarcated units of content having at least one learning objective. They are independent of other learning objects and communicate their learning objective. Dividing the content into such learning objects and describing them through standard meta-data can make them highly reusable and portable.

There is no existing industry standards based e-learning model that embeds a sound instructional design strategy and automates the linking of personnel in an organization to learning objects. Also, there has been no work done in investigating the costs of a learning object-based e-learning project. This study thus has two main contributions: (1) the development of an e-learning model for an industrial enterprise that is not only specific to the instructional design needs of the organization, but is also compliant with industry standards; and (2) the investigation of the cost differential of an e-learning project developed with learning objects when compared to an e-learning project without learning objects.

The research approach was to develop a course using learning objects and to use the experience to develop an e-learning model that an organization can implement to create and deploy a learning object-based repository and/or curriculum. The reuse of learning objects measured was encouraging as it indicated cost savings. The learning object reuse was found out to be 19% for a single course developed. The results were even more encouraging considering that there was no prior availability of a learning object repository from the course could draw from. Overall, the project costs were saved by more than 15%.

Biography

Harmanpreet Singh received his Bachelors in Engineering (Computer Science) from Punjab Technical University, India in 1999. He worked for a year in India in an educational institute designing an online teaching program. In the Fall of 2000, he joined the Masters program of Computer Science in North Carolina State University, Raleigh, North Carolina. He has been a research assistant to Dr. Laurie Williams since the Spring of 2001. He also worked as a summer intern in ABB at Centennial Campus, Raleigh under his manager, Dr. Aldo Dagnino. Harmanpreet's interest in the field of e-learning has encouraged him to do this study.

Acknowledgements

There have been a lot of people who have supported me during this study. I would first like to thank my advisor Dr. Laurie Williams who trusted me and let me do work in a field that is not yet a part of much academic research. She guided me with her keen insight that helped me all the way. I would also like to thank Dr. Aldo Dagnino and Dr. Wilbur Meier who gave me the opportunity to work on the e-learning project and provided me all the resources to accomplish my goal. They helped arrange for most of the meetings with the key people involved in the study which otherwise would not have been possible. I would also like to thank my committee member, Dr. Tom Miller.

A special mention to Prahant Bhardwaj, a senior software engineer at Centra who guided me on the technicalities involved in the study. This work would not have been possible without Prashant's assistance. Last but not the least, I would thank Harvi Singh, the founder of Mindlever.com and a visionary. He showed me the way into the future of e-learning that helped me think in the right direction for the study.

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Acronym Listing

Table 1: Acronym Listing

ADL	Advanced Distributed Learning
AICC	Aviation Industry Computer-Based Training Committee
ALO	Atomic Learning Object
CLO	Composite Learning Object
DoD	Department of Defense
DTD	Document Type Definition
HTML	Hypertext Markup Language
LCMS	Learning Content Management System
LMS	Learning Management System
RLO	Reusable Learning Object
RIO	Reusable Information Object
SCO	Sharable Content Object
SKA	Skills, Knowledge, Attitude
UID	Unique Identifier
W3C	World Wide Web Consortium
XML	eXtensible Markup Language

1 Background

This chapter walks through the concept of e-learning and the progress that has been made in this field. It explains different techniques used in e-learning, various concepts introduced in the industry and where e-learning stands today. It also discusses the e-learning standards being proposed and developed by government and other private organizations.

1.1 Introduction to e-learning

> *The only thing that gives an organization a competitive edge..... is what it knows, how it uses what it knows, and how fast it can know something new.*
>
> *`Laurance Prusak, IBM [1]*

There is no doubt that the knowledge of an organization is one of the deciding factors for the success of the organization. But how does one really impart and disseminate quality knowledge in an organization? Training the employees with targeted skills and tools is essential. Historically, the most prevalent training technique has been the traditional classroom training environment. But, the basic problem with classroom training is the time involved in changing and updating the classroom course for all locations within the company with a change in technology. [1, page 8]. Consider another fact. Twenty years ago, a classroom course for a demanding technology had a shelf-life of several years. Once the course was developed, it was conducted throughout the organization and the benefits were reaped for years. Now, with technology changing so rapidly, a course cannot effectively remain intact for years or even months. Before a classroom course is completely designed to instruct in a technology, a new technology takes over, thus, obviating the need for the course. Further, classroom training requires a physical location (a presentation room), not more than a limited number of learners, and a set of resources like projectors and assistants before it can be conducted. Learners and instructors may need to travel to attend the course. All this adds to the overhead of the classroom-based environments.

E-learning can demonstrate improvement and cost savings when compared with classroom training. Rosenberg defines e-learning: "E-learning refers to the use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance." [1] As John Chambers, CEO of Cisco Systems puts it, "The two great equalizers in life are the Internet and Education." Using the power and the reach of the Internet, e-learning has the potential to revolutionize the structure of learning. Additionally, shorter development times and the once-developed-use-anywhere attributes of e-learning cut the cost of development and the delivery time. [1]

There are two basic types of e-learning methodologies:

Synchronous e-learning: Learning is mainly under the guidance of an instructor, although students and the instructor might be geographically dispersed. Students have a predetermined time for such type of learning (e.g. video conferencing, web seminars etc.)

Asynchronous e-learning: A learner can take the course at anytime and anywhere he/she has access to the Internet. Interaction between teachers and students occurs intermittently with a time delay.

The scope of this study is that of asynchronous e-learning. Following are some of the benefits of asynchronous e-learning [1]:

1. Lower cost: Although E-learning introduces new types of costs, the economies of scale come into play and with large number of students taking these courses, once developed-use-anywhere attribute of e-learning can save costs. “E-learning eliminates costs by allowing a specialist in Sacramento to train an entire group in Singapore without leaving the office” [12]
2. Up-to-date content: easier to update content as it resides at one centralized location.
3. Courses are available at anytime and anywhere the Internet is accessible.
4. Consistency of courses is maintained for all users: Because all users are taking only one common version of the course, consistency is maintained.

   > *e-Learning also provides consistent training across an organization. While different instructors have different approaches to teaching a particular topic and present training of varying quality, giving students access to e-learning ensures training is consistent from student to student.* [13]

5. Scalability in terms of number of users: Asynchronous e-learning is not restricted by the number of users learning the course at any given time.

   Current state-of-the-practice methods of developing asynchronous e-learning have their own drawbacks:

   1. No common standards for creating content: Authors create asynchronous e-learning courses, but they do not follow any common standard for developing and deploying courses so as to make them portable.
   2. No reusability: Over the years, authors have been creating content without giving much thought to the idea of reuse. As Stephen sums it,

*It makes no financial sense to spend millions of dollars producing multiple versions of similar learning objects when single versions of the same objects could be shared at a much lower cost per institution. [*9]

There are various skills and tools required to develop asynchronous e-learning courses that vary in costs. Typical costs in an asynchronous e-learning course, adapted from Bates [8] are listed below:

Table 1.1: Typical costs of asynchronous e-learning course by Bates

Subject Experts	$400 / day
Internet Specialist	$300 / day
Graphics and Interface Design	$300 / day
Overhead	25%

Bates is quite conservative in estimating the costs. Nonetheless, if reuse can cut the above costs, it cannot be ignored. The new concept of learning objects has shown the possibility of revolutionizing the asynchronous e-learning industry by addressing the issues of cost, reusability and interoperability. [2]

1.2 Learning objects

With the increase in number of e-learning courses being developed, there is significant cost and duplicated effort. Clark observes that "a traditional training approach that rests on static, monolithic courses no longer meets the performance requirements of modern organizations." [16] There needs to be a way to reuse existing knowledge and courses. This is where the concept of learning object (LO) comes in. The most widely used definition of LO is given by IEEE-Learning Technology Standards Committee: ". . . any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning." [18]

In other words, a LO is a reusable instructional module deliverable through technology-supported learning. For this study, we keep the scope of deliverable technology to be only the Internet. A LO refers to a learning resource which has at least one learning objective. A LO can be a single page of text, a graphic, animation, simulation or an audio/video element with some learning objective. Alternatively, a LO can be a composition of other learning objects. For example, a LO can be a topic explaining "How to identify various parts of the car engine" or a LO could be a complete course named "Designing a car engine from scratch" which encompasses the first LO. It is to be noted that the size of both these objects could vary remarkably. Ideally, the LOs are away from the context in which they are being used. That means that they are created with a general learning objective in mind rather than for a single learning scenario.

With the advancements in asynchronous e-learning, Cisco Systems Inc. has developed a successful Reusable Learning Object Strategy [6] based on "Reusable Learning Objects" (or RLOs). "Cisco Systems, Inc. recognized a need to move from creating and delivering large inflexible training courses, to database-driven objects that can be reused, searched, and modified independent of their delivery media. This effort is called the Reusable Learning Object" strategy. [6] They employ their own meta-data tagging elements for their internal needs. That means that the content they would produce and the schemes they use to deploy it lets them make the content portable and reusable within their organization.

1.3 Learning Object Meta-data

Markup languages like XML are becoming universal for data information exchange over the web. XML tags can be used to describe information. The description of information could be a specification of the type of information, its origin, its possible use, and so forth. This same technique is applied to describe LOs and thus is called learning object meta-data. "Meta-data is used to describe what the object contains, much like a label lists the ingredients and nutritional value of a box of cereal."[7].

Meta-data is what makes the LOs reusable. An LO described with a specific meta-data can be easily searched and reused by somebody else who understands that meta-data. Thus, a standard meta-data scheme can make LOs reusable and interoperable. Cisco's RLO strategy defines the meta-data as "RLO is tagged with meta-data that describes reusable learning object's function and associated objects." [6] Some of the tags defined by reusable learning object strategy are that of title, objective, strand, job task, author name and creation date.

1.4 Assets

Assets are electronic representations of media or other pieces of data that can be delivered to a Web client [2]. Assets are the raw media in the digital form that is tagged with meta-data to be stored in the content repository. They can then be searched and retrieved just like LOs. The difference between assets and LOs is that assets do not have any learning objective. They are simply content in some form of digital media like text, animations, images etc. A LO consists of various assets. An example of an asset is an image of the car engine that could be used in the LO named: "How to identify various parts of the car engine." The image doesn't help accomplish any learning objective all by itself but can be used in the LO to serve its (LO's) purpose.

1.5 Learning Management System

A learning management system (LMS) is software that runs synchronous or asynchronous e-learning courses, manages users, their performance etc. Brennan et.al. define an LMS as: "An LMS takes a centralized, organizational approach to learning in that it schedules and registers students for full online and offline courses, launches e-learning courses, and tracks learner progress through these courses." [7] An LMS is a database driven software package that takes care of the administrative tasks such as keeping records related to learners as well as LOs.

1.6 Specifications and Industry Standards

The issue of standards arises from the need for interoperability of learning content. Two different organizations cannot use the same LOs if there is no common understanding of the information about how they are to be used. If one organization uses its own type of meta-data tags for its LOs, there is no way that another organization can use them. Many government and private organizations have tried to come up with suggestions and specifications. Some of them are listed below:

1.6.1 AICC

The Aviation Industry Computer-Based Training Committee (AICC) is an association of technology-based training professionals. "The AICC develops guidelines for aviation industry in the development, delivery, and evaluation of CBT and related training technologies." [10]. AICC was one of the pioneers in creating specifications for meta-tagging and in reusing LOs. Although their work was a good contribution to the industry, their specifications are not as widely spread as that of other organizations like IMS Global Consortium and Advanced Distributed Learning (ADL).

1.6.2 IMS meta-data specification

IMS Global Learning Consortium, Inc. (IMS) is a global consortium with members from educational, commercial, and government organizations. IMS develops and promotes open specifications for facilitating online distributed learning activities such as locating and using educational content, tracking learner progress, reporting learner performance, and exchanging student records between administrative systems [5]. It defines meta-data tagging of LOs and content packaging specifications so that content is identifiable and interoperable.

1.6.3 SCORM

Sharable Content Object Reference Model (SCORM) was started by the Department of Defense (DoD) and the White House Office of Science and Technology Policy (OSTP) and the initiative of Advanced Distributed Learning (ADL) [3]. "SCORM defines a Web-based learning Content Aggregation Model and Run-time Environment for learning objects" [2]. SCORM borrows and then modifies some of the technology developments from other standards organizations like:

1. AICC: Aviation Industry Computer-Based Training Committee
2. IMS: IMS Global Learning Consortium
3. IEEE-LTSC: Institute of Electrical and Electronics Engineers; Learning Technology Standards Committee

4. ARIADNE: Alliance of Remote Instructional Authoring and Distribution Networks for Europe.

SCORM adds some of its own concepts and provides a specification which helps the content developers as well as the Learning Management System (LMS) vendors to develop an end product. Because SCORM is one of the most popular standards in the industry, we used SCORM version 1.2 for this study.

1.7 Putting the pieces together: How learning objects work

As discussed earlier, learning content can be divided into LOs, and can be described with XML meta-data. The author decides how and where to demarcate content to form LOs so that there is some level of reusability that can be achieved with minimum meta-data overhead. These LOs are placed in a relational database, called a learning content repository, attached to a learning content management system (LCMS) where it is easy to store, search and retrieve these LOs.

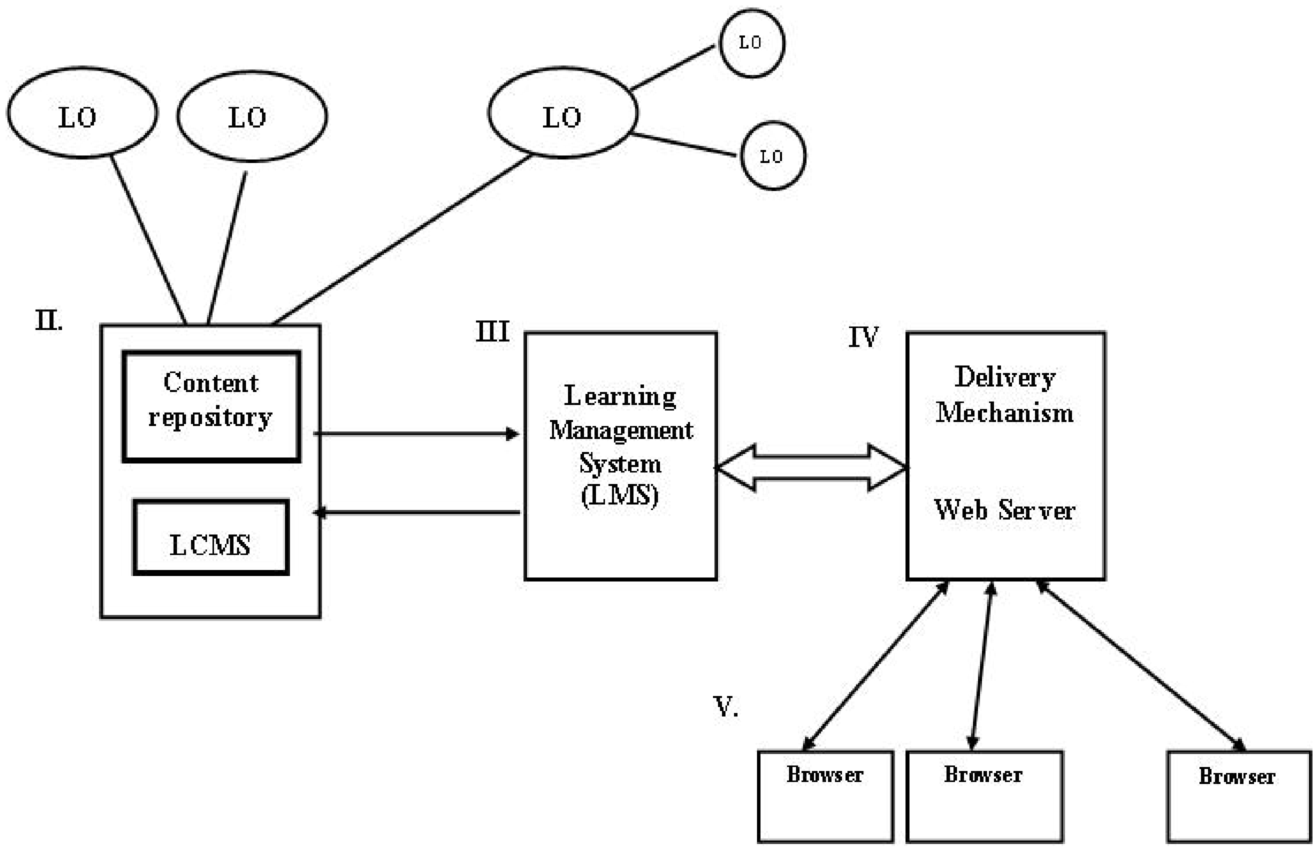

Figure1.1: How learning objects work

Figure 1.1 above depicts a complete LO-based e-learning system that shows the life cycle of learning objects from construction to delivery and tracking. Authors focus on developing standalone LOs. They may develop them anew or assemble from pre-existing finer grained LOs. These LOs are described with SCORM specific XML meta-data tags. Once LOs have been tagged, they are called Sharable Content Objects or SCOs by SCORM. A SCO is a LO tagged with meta-data to make it SCORM compliant. (For a more formal definition and further details of SCORM, please see Appendix C) A content repository stores these LOs. The learning content is then retrieved (from LCMS) and assembled dynamically (by a routine inside the LMS) or statically (by the author) to develop courses. The meta-data helps in easy and precise identification of the learning objects in the repository. The LMS controls the runtime environment of the system. It manages tasks like maintaining user profiles, tracking user input, and reporting results. The interface of the course (assembled from LOs) with the learner is through a Web browser served by a Web Server.

1.8 Research motivation and direction

The concept of the LO has been around since 1998, based on the work done by Spohrer and his associates on educational object economies [20]. There have been specifications for creating LO based courses for more than a year since the release of SCORM 1.1 (January 2001). However, hitherto there is no documented results of deploying a SCORM-based e-learning model that incorporates a sound instructional design strategy and a system of linking employees' skills to LOs. One of the reasons for the lack of widespread interest in LO based e-learning model is that there are not many studies showing significant cost savings with LOs. Another reason involves the risk of investing in new technology and setting up a whole new infrastructure. This study focuses on developing a LO based, SCORM compliant model. To be more precise, this study examines the following hypotheses:

- An e-learning model can be developed which both achieves its instructional design requirements and conforms to industry standards.
- Utilizing an LO-based e-learning model can reduce project costs and make e-learning more affordable for organizations.

These hypotheses are tested by the following steps:

- Creating a course based on LOs, meta-tagging the LOs to create SCORM-specific SCOs and meeting the instructional design requirements of the enterprise
- Testing for SCORM compatibility
- Measuring reuse of content
- Using cost metrics to analyze the cost of e-learning project with and without LOs

2 E-learning Model for an Industrial Enterprise

This chapter first describes the training needs of the organization and the creation of a LO-based e-learning model specific to those needs. The model modifies some of the SCORM 1.2 meta-data tags for customization while conforming to SCORM 1.2. Two new concepts, Atomic Learning Object^{SM} (ALO^{SM}) and Composite Learning Objects^{SM} (CLO^{SM}) that were created through this research will be explained. The various elements of the model are then explained. Finally, the four levels of the SCORM-based e-learning model are graphically depicted.

2.1 Introduction

As a part of this study, a course was to be created, employing the theory of LOs which enabled content reuse. The course also had to be SCORM 1.2 compliant so that it was capable of deployment virtually over any given SCORM 1.2 compliant LMS. The experience was then used to develop the e-learning model.

2.2 Problem Definition

The course had five different topics for three different types of learners based on their level of technical expertise. This is graphically depicted in figure 2.1

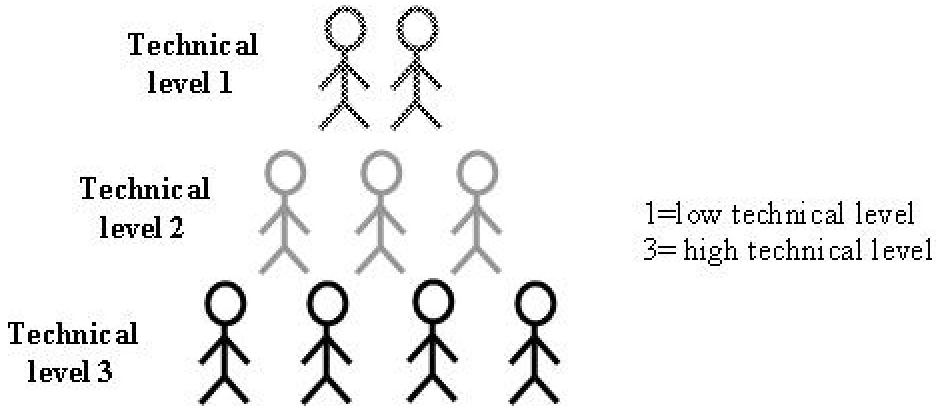

Figure 2.1: Three different kinds of employees with different technical levels

A traditional e-learning course development technique would develop three "hardwired", non-portable courses for each type of learner. But there was overlapping learning content among these three categories of personnel. The question was, could we reuse the content developed? Theoretically, it was possible. We did not need to have three entirely distinct courses but instead, three different courses with some overlapping "topics". This is where the concept of a "learning object" steps in.

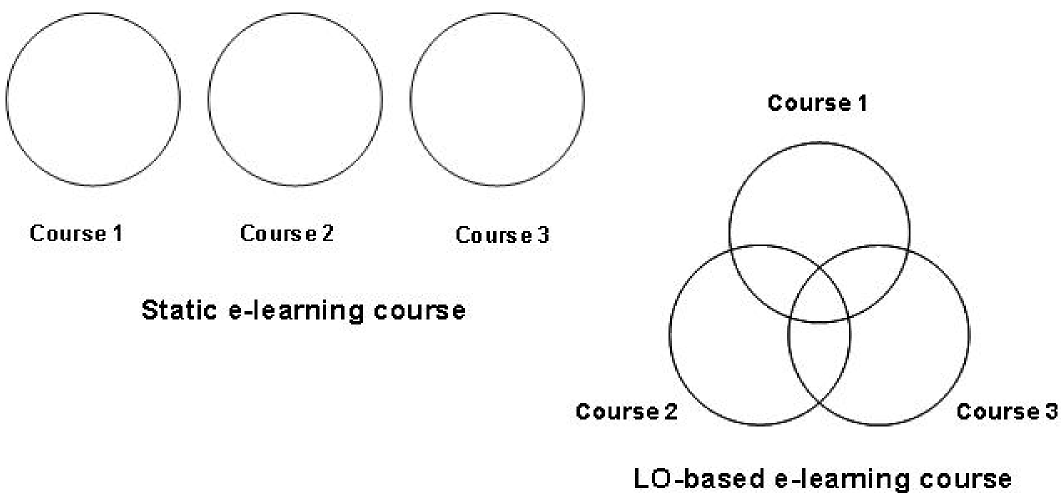

Figure 2.2: Effort for creating e-learning course with and without LOs

2.3 How the model was reached

Two steps of this study were:

1. To develop an e-learning model that was very specific to the enterprise's needs i.e. solving the problem defined.
2. To make the course industry standards compliant vis-à-vis SCORM. The latest version of SCORM available was SCORM version 1.2 released on October 1st 2001 [2]

First, scope of the LOs had to be very specific. Recalling from section 1.2, the definition of a LO is does not really specify the size of an LO. It does not specify the number of learning objectives an LO has. It simply says that an LO is a "chunk" of learning that has *one or more* learning objectives. For this study, the LO concept was further subdivided into two more precise definitions:

- ALO^{SM}: "Atomic Learning Object" refers to a learning resource, which has one and only one learning objective, for example, a topic inside a chapter which does not have more sub-topics. An ALO cannot be broken down further to get more ALOs.
- CLO^{SM}: "Composite Learning Object" is a collection of two or more ALOs and/or other CLOs. As an example, a chapter with several topics (ALOs) can be considered as a CLO. Another example could be a course consisting of chapters (CLOs) which further consists of Topics (ALOs).

It is to be noted here that once tagged with meta-data, SCORM views all learning objects (including ALO and CLO) as Sharable Content Object (SCOs). A SCO represents a collection of one or more assets that utilizes SCORM Run-Time Environment to communicate with Learning Management Systems (LMSs). [2]

2.4 Elements of the model

This section describes how the e-learning model was approached, step by step, considering the various needs of the organization. The various tasks to accomplish our first step (develop an e-learning model that was very specific to the enterprise's needs) were identified as:

- Determine instructional design to be used
- Determine CLOs & ALOs to be created.
- Determine assets to be developed.
- Link ALOs with the job positions.
- Make ALOs and CLOs SCORM compliant but still customized to the instructional design used.

2.4.1 Instructional Design Strategy

Instructional Design is a branch of knowledge that deals with research and theory about instructional strategies and the process for developing and implementing those strategies. Instructional Design is the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. It is the entire process of analysis of learning needs and goals and the development of a delivery system to meet those needs. It includes development of instructional materials and activities; and tryout and evaluation of all instruction and learner activities. [17] A fairly basic but powerful instructional design strategy of pre-test, content, and assessment was used. These elements are explained further.

1. Pre-test: A quiz or a test that the learner takes to determine if he/she is ready to learn the content. This can be a very important part of the whole learning process. As

observed by Jerrold E. Kemp et al. “Pretests heightens the learner's awareness of the content by serving as cues to the key points.” [11]

2. Content: The piece of instruction (ALO/CLO) that the learner is exposed to. It has the following sub-elements:
   - Overview
   - Objectives
   - Subject matter
3. Assessment: A quiz that the learner takes to demonstrate the skills learnt from the content.

For creating ALOs, authors must answer the following four questions:

1. What is the topic?
2. Does this set of instructional information (content) describe the topic completely?
3. What are the objectives of the topic?
4. Does it have any dependencies?

Note: Dependencies are different from prerequisites. There should be no dependencies within the ALO. E.g. if there are two ALOs in a chapter, and an example is used to explain one ALO, then by definition, the second ALO cannot refer to the example used in the first ALO.

2.4.2 Creating ALOs and CLOs

The next step was to create the actual ALOs to be used for the study. The manufacturing department’s training table (see Appendix A for table) was produced which linked each job position to a certain number of skills that need to be acquired for that job. Not every kind of employee listed in the table was equally technically competent (e.g. there were managers as well as engineers that need to acquire similar skills but with different levels of technical background). This gave us another reason to further demarcate ALOs. Table 2.1 lists the categories of personnel for which the ALOs were produced:

Table 2.1: Three Categories of Personnel

Category #	Category Name	Description
1.	Top-Managers	BA-Division Management
2.	Middle-Managers	BAU-Management
3.	Engineers	Engineers and supervisors
		Production Associates

BA: Business Area
BAU: Business Area Unit

Once the personnel were categorized and the list of topics had been made, the ALOs were produced, one ALO for each topic for each category. Table 2.2 through Table 2.4 lists the ALOs that were produced:

Table 2.2: ALOs for Top managers

Category 1: Top-Managers		
Category #	**Unique identifier**	**ALO Name**
1.	PK01	Pull Production and Kanbans System

2.	VM01	Visual management and waste elimination
3.	FM01	Flow Manufacturing
4.	CM01	Cellular Manufacturing
5.	FF01	Focused Factories
6.	PRE01	Pre-Test for category 1
7.	AA01	Assessment for category 1

Table 2.3: ALOs for Middle-Managers

Category 2: Middle-Managers		
#	**Unique identifier**	**ALO Name**
1.	PK02	Pull Production and Kanbans System
2.	VM02	Visual Management and Waste Elimination
3.	FM01	Flow Manufacturing
4.	CM02	Cellular Manufacturing
5.	FF01	Focused Factories
6.	PRE02	Pre-Test for category 2
7.	AA02	Assessment for category 2

Table 2.4: ALOs for Engineers

Category 3: Engineers		
#	**Unique identifier**	**ALO Name**
1.	PK03	Pull Production and Kanbans System
2.	VM03	Visual management and waste elimination
3.	FM01	Flow Manufacturing
4.	CM03	Cellular Manufacturing
5.	FF01	Focused Factories
6.	PRE03	Pre-Test for category 3
7.	AA03	Assessment for category 3

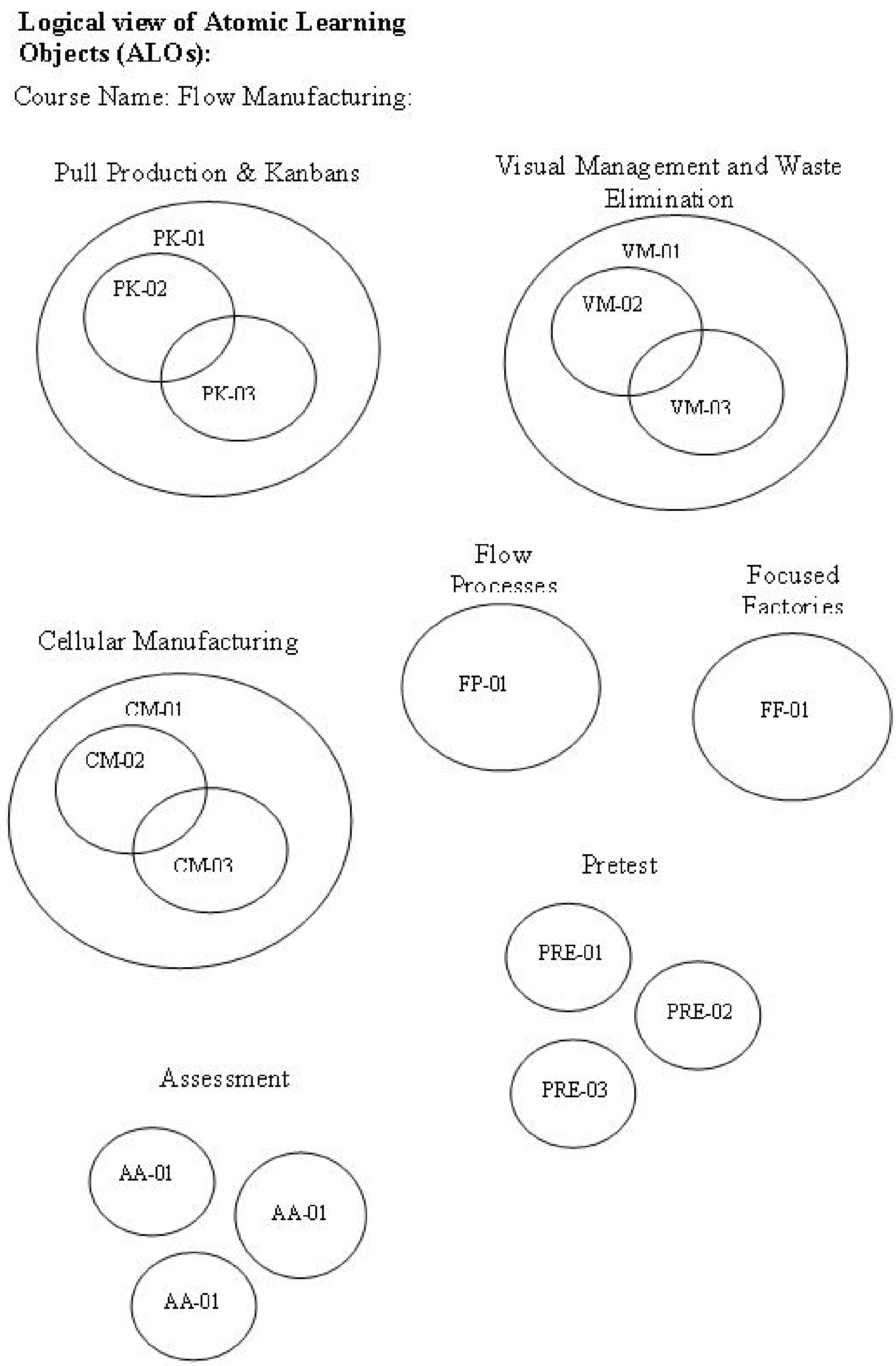

Figure 2.3: Logical layout of ALOs

Figure 2.3 shows the logical view of the ALOs created.

As it can be seen in Tables 2.2 through 2.4, the total number of unique ALOs created were 17:

7 new ALOs for category 1

5 new ALOs for category 2 (ALOs FM01 and FF01 were reused)

5 new ALOs for category 3 (ALOs FM01 and FF01 were reused)

2.4.3 Creating Assets

As described in section 1.4, assets are simply the raw media in the digital form wrapped with meta-data. Assets include but are not limited to video, audio, image or animation files. SCORM compliant meta-data around assets makes them reusable too. For the case study of creating the course, a number of assets were created that were capable of being stored in a content repository. They were image and animation files wrapped with SCORM meta-data. These assets were reused in the course development at different levels. The next chapter studies the amount of asset reuse in detail.

2.4.4 Job-Skills-ALO Map

The next step was to construct a map so as to link each employee to certain ALOs. The approach taken was to list the skills related to each job position for the given department (see Appendix A for the Manufacturing department's training table). Based on the table and the ALOs produced, database structure shown in figure 2.6 was developed:

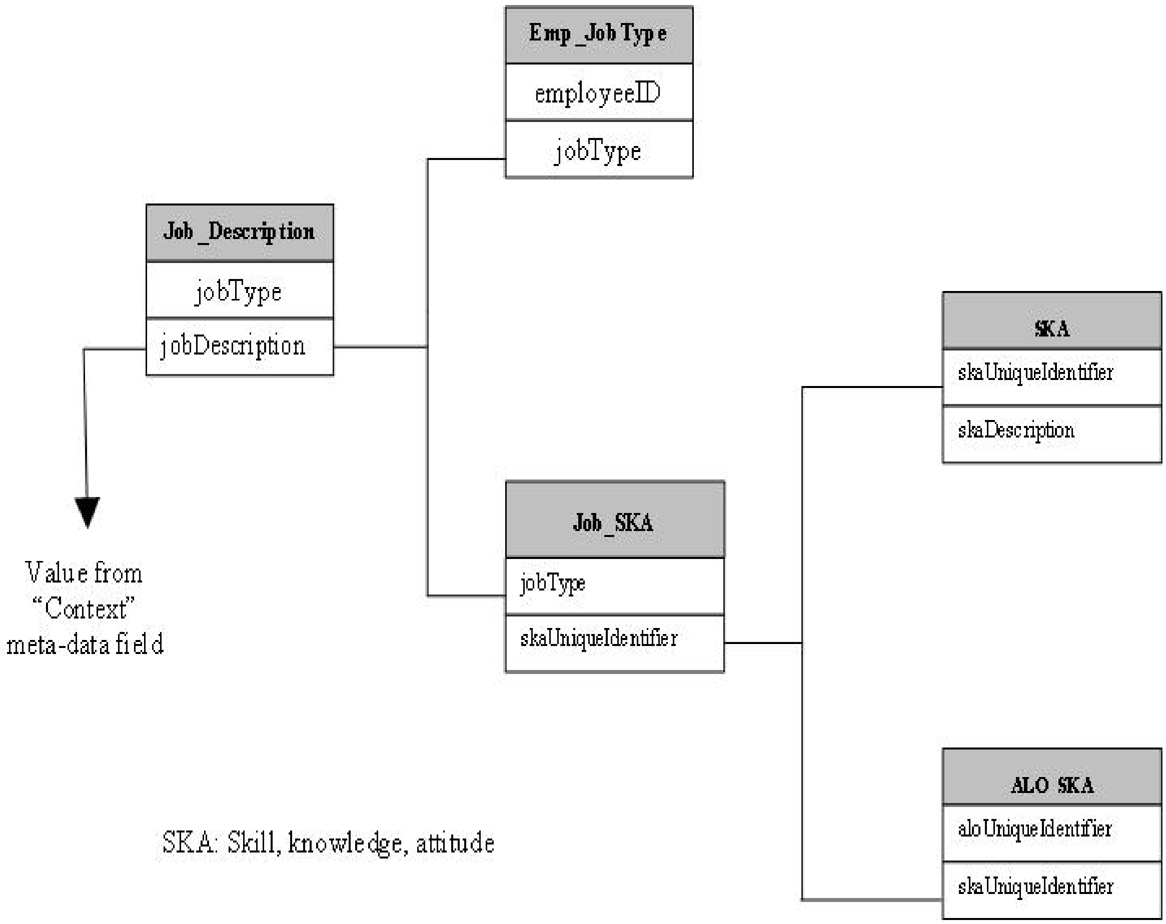

Figure 2.4: Job-Skills-ALO database structure representation

Explanation of database elements in figure 2.4:

JobType: This is the value from the meta-data tag name called "Context". *SCORM Compliance and Customizatiom* discusses about this element.

JobDescription: The description of that job type. In this study, its

i. Top-Managers
ii. Middle-Managers
iii. Engineers

skaUniqueIdentifier: A unique Identifier for each skill listed

skaDescription: Description of each skill.

aloUniqueIdentifier: Unique identifier of each ALO (which is the unique identifier of the SCO). SCORM meta-data tag used:

empId: Each employee's unique Identification number in the company

2.4.5 SCORM Compliance and Customization

As for the first step of the research, that all content should be SCORM 1.2 compliant, assets and the ALOs created were validated through SCORM 1.2 Content Aggregation schema [2] and passed the SCORM "Meta-Data Conformance Test" [14].

To reach the second step of the study (the model customizes to enterprise's requirements), this model made some of he optional SCORM tags mandatory so as to employ the instructional design strategy and the Job-Skills-ALO map based on the enterprise's requirements. The SCORM 1.2 Content Aggregation Model defines certain number of meta-data tags each for meta-tagging assets and ALOs. Some of them are mandatory and others are optional. To make content (asset/ALO/CLO) SCORM 1.2 compliant, at least the mandatory meta-data tags should be present [2]. To implement the instructional design strategy and Job-Skills-ALO map, some of the optional tags were used and made mandatory in the SCORM 1.2 Content Aggregation schema. The result was a new schema. We call it the "E-learning model schema." Any content that had to conform to the e-learning model now had to be validated through two schemas:

1. SCORM 1.2 Content Aggregation schema
2. E-learning model. schema (see Appendix E: Schema and XML files for more details)

The assets and ALOs developed for the study were validated through both the schemas. The validation of all content (assets/ALOs/CLOs) positively tests the first hypothesis explained in section 1.8. The model now encompasses the requirements of the enterprise as well as complies with SCORM 1.2.

The Details of the meta-data tags that were made mandatory in SCORM 1.2 Content Aggregation schema are described below. These elements were optional for SCORM 1.2 Content Aggregation schema but are now mandatory for "E-learning model schema." A table with a complete listing of all tags in both the schemas can be seen in Appendix D.

I. Meta-data tag name in SCORM 1.2 Content Aggregation: Learning Resource Type

- Location in SCORM 1.2 Content Aggregation schema:

  lom > educational > learningresourcetype

- Occurance in SCORM Content Aggregation schema: 0 or more
- Description in SCORM: Specific kind of resource, most dominant kind first.
- Added vocabulary for e-learning model:

1. *"Pretest"*
2. *"Content"*
3. *"Assessment"*

- Description in e-learning model: The new vocabulary makes this tag mandatory for the e-learning model. This value can be used by the LMS to know whether this ALO is a pretest, content or an assessment module. Based on this value, the LMS can make a decision or can invoke a subroutine.
- Occurence in e-learning model: 1 or more (mandatory)

II. Meta-data tag name in SCORM 1.2 Content Aggregation: Context

- Location in SCORM 1.2 Content Aggregation schema:

  lom > educational > context

- OccuranceOccurrence in SCORM 1.2 Content Aggregation schema: 0 or more
- Description in SCORM: The principal environment within which the learning and use of this resource is intended to take place.
- Added vocabulary for e-learning model:

1. *"Technical Level One"*
2. *"Technical Level Two"*
3. *"Technical Level Three"*

- Description in e-learning model: The new vocabulary makes this tag mandatory for the e-learning model. This value can be used by the LMS to know as to which category this ALO belongs to. The three categories defined by the e-learning model were:

1. Top-managers
2. Middle-managers
3. Engineers

Based on this value, the LMS can make a decision or can invoke a subroutine.

- Occurence in e-learning model: 1 or more (mandatory)

III. Meta-data tag name in SCORM 1.2 Content Aggregation: Relation

- Location in SCORM 1.2 Content Aggregation schema: lom> relation
- Occurance in SCORM 1.2 Content Aggregation schema: 0 or more
- Description in SCORM: Nature of the relationship between this resource and the target resource, identified by 7.2: Relation.Resources.
- Added vocabulary for e-learning model:
  1. *"HasPretest"*: Means that the specific ALO with this value has a pretest.
  2. *"IsPretestFor"*: Means that the specific ALO with this value is a pretest ALO for another ALO.
  3. *"HasNoPretest"*: Means that the specific ALO with this value has no pretest ALO at all.
  4. *"HasAssessment"*: Means that the specific ALO with this value has an assessment ALO.

5. *"IsAssessmentFor"*: Means that the specific ALO with this value is an Assessment ALO for another ALO.
6. *"HasNoAssessment"*: Means that the specific ALO with this value has no assessment ALO.
7. *"IsNeutral"*: Means that the specific ALO with this value no pretest or assessment ALOs.

- Description in e-learning model: The new vocabulary makes this tag mandatory for the e-learning model. This value can be used by the LMS to run the pretest, if any, associated with a resource. Based on this value, the LMS can make a decision or can invoke a subroutine.
- Occurance in e-learning model: 1 or more.

Following table summarizes the customization that was done to SCORM:

Table 2.5: List of customized SCORM 1.2 meta-data tags

S.No.	Location in SCORM 1.2 Content Aggregation Model	Name given by SCORM 1.2 Content Aggregation Model	Content Aggregation	SCO	Asset
1.	5.2	learningresourcetype	O (M)	O (M)	O
2.	5.6	Context	O (M)	O (M)	O
3.	7.0	Relation	O (M)	O (M)	O

O	Optional SCORM 1.2 tags
M	Mandatory SCORM 1.2 tags

Appendix D lists the table with all the meta-data of SCORM Content Aggregation Model given by SCORM 1.2

2.5 Summary of the e-learning model

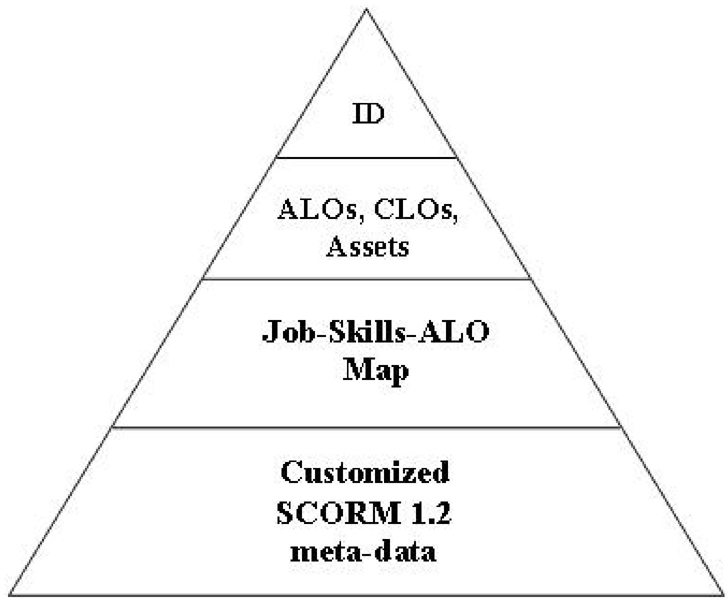

Figure 2.5: Different layers (elements) of the e-learning model

Figure 2.5 shows the graphical representation of the e-learning model developed. There are basically four layers of the model. The top layer, layer one is the "Instructional Design" layer which encompasses the Instructional design strategy of the organization. We used the instructional design strategy of pretest, content and assessment. Layer two encompasses the digital content to be created in the form of ALOs, CLOs and assets. Layer three consists of the Job-Skills-ALO map that helps organization deliver the e-learning courses to its employees in an effective manner. Layer four focuses on the deployment of digital content in the SCORM 1.2 compliant form as well as customizing SCORM 1.2 meta-data tags to the instructional design chosen and the Job-Skill-ALO map created. Layers one, two and three are independent of each other and layer four depends on all the three layers above. The e-learning model thus created proves the first hypothesis of this study to be true. There now exists an e-learning model that is customized to an enterprise's needs and still being SCORM 1.2 compliant.

3 Reuse and E-learning Project Costs

This chapter analyzes the total e-learning project costs using cost metrics. The amount of reuse is calculated and the difference of cost between a static e-elarning project and an LO-based e-learning project. The discussion assumes that there is an infrastructure for e-learning already available inside the organization.

3.1 Amount of reuse

First, the percentage of reuse was calculated in the development of the sample course. In our case study, all the SCOs (meta-tagged ALOs) needed to be created; none could be reused from pre-existing ones because these were the first LO-based courses in this particular organization. As a result, the findings are conservative because over time organizations that are commited to creating and storing ALOs can develop an impressive repository of ALOs that can be reused.

3.1.1 Asset level reuse

Asset level reuse is the reuse of assets when the course was developed. For this study we used a term called

AssetType "X" = Type of asset X; where X could be video, audio, animation, simulation, image etc.

In calculating asset level reuse, the following variables are used:

N_{TAsset} = Total number of assets (new + modified + reused without modification)

$F_{ModifyA[i]}$ = Asset Modification Factor. Here A[i] denotes a specific asset as if they are stored as an array of assets. It is a measure of the amount of modification before it can be reused as an appropriate asset. Its value lies between 0 and 1.

Mathematically,

$$F_{ModifyA[i]} = 1 - \frac{PercentageOfAssetModification}{100}$$

PercentageOfAssetModification is the percentage of modification in terms of development time required before it can be reused as an appropriate asset. The value of this factor is determined by the asset developer.

If $F_{ModifyA[i]} = 0$, the AssetType has to be re-created from scratch.

If $F_{ModifyA[i]} = 1$, the AssetType does not need any modification and can be reused as is.

If $0 < F_{ModifyA[i]} < 1$, the higher the value of. $F_{ModifyA[i]}$, the less the modification required.

We examined the asset reuse in our case study.

Total number of new assets developed from scratch	=	6

Number of assets used to create course for:

Category 1 course	=	6
Category 2 course	=	4
Category 3 course	=	4
Total number of assets used	=	14

Total number of assets reused <u>after modification</u> = 0

Therefore # of assets reused <u>with or without modification</u>:

$$N_{AssetReuse} = \sum_{i=1}^{n} (N_{NewA[i]} \times F_{ModifyA[i]})$$

Where $N_{NewAsset[i]}$ = New or modified Asset A[i], e.g audio[1], video[3]

Equation 3.1

etc. E.g. If for creating some course (other than in our case study) there were 5 total assets. One audio was reused that required 50% modification, another audio that required 20% modification, a video that required 75% modification, and one animation that was reused without any modification

$$N_{AssetReuse} = (0.5 + 0.8 + 0.25 + 1)$$

$$= 2.55$$

In the case study, there was no partial reuse (modification of assets) observed, therefore $F_{ModifyA[i]} = 1$ for each asset..

$$N_{AssetReuse} = 14 - 6 = 8$$

$$\text{Asset level reuse reuse} = \frac{\text{Total \# of assets reused } (N_{AssetReuse})}{\text{Total \# of assets used } (N_{TAsset})}$$

$$= \frac{8}{14}$$

$$= \mathbf{57.1\%}$$

3.1.2 SCO level reuse

Similarly, the SCO-level reuse is the percentage of SCOs that were able to be reused when the course was developed. To examine SCO reuse, the following terms are used:

N_{TSCO} = Total number of SCOs (new + modified + reused without modification)

$F_{ModifySCO[j]}$ = SCO Modification Factor. It is a measure of the amount of modification. Its value lies between 0 and 1.

Mathematically,

$$F_{ModifySCO[j]} = 1 - \frac{PercentageOfSCOModification}{100}$$

PercentageOfSCOModification is the percentage of modification in terms of development that is required in a SCO before it can be reused as an appropriate SCO. This can be determined by the author and the media developers.

If $F_{ModifySCO[j]} = 0$, the SCO has to be re-created from scratch.

If $F_{ModifySCO[j]} = 1$, the SCO does not need any modification and can be reused as it is.

If $0 < F_{ModifySCO[j]} < 1$, the higher the value of. $F_{ModifySCO[j]}$, the less modification required.

We examine the SCO reuse of our case study. In our case study there was no partial reuse (modification of SCOs) observed, so $F_{ModifySCO[j]} = 1$ for all SCOs.

Let N_{NMSCO} = Total number of new SCOs + Total number of modified SCOs

In our case study:

SCOs required to build each course (Category 1, 2, and 3) = 7/course or 21 total.

Number of new SCOs developed from scratch (i.e. $F_{ModifySCO} = 0$) to create course for:

Category 1	=	7	
Category 2	=	5	(Two SCOs were reused from category 1)
Category 3	=	5	(Two SCOs were reused from category 1)
Total new SCOs	=	17	

developed from scratch

Total SCOs modified for reuse = 0

Therefore # of SCOs reused (<u>with or without modification</u>) =

$$N_{SCOReuse} = \sum_{i=1}^{m} (N_{NewSCO[j]} \times F_{ModifySCO[j]})$$

Where $N_{NewSCO[j]}$ = New or modified SCO e.g. SCO[1], SCO [5] etc.

Equation 3.2

In our case study, we did not modify any SCO,

$$N_{SCOReuse} = 21 - 17 = 4$$

$$\text{Percentage of reuse} = \frac{\text{Total \# of SCOs reused } (N_{SCOReuse})}{\text{Total \# of SCOs used } (N_{TSCO})} = \frac{4}{21} = \mathbf{19\%}$$

Considering that there was no off-the-shelf (or a pre-existing SCO repository) available, the SCO level reuse is quite significant.

3.2 E-learning Project Costs

Various parameters must be considered to calculate the cost of creating an e-learning project. Notable instructional designer Lori Mortimer defines a unit of LO as, "a chunk of learning that takes no longer than 15 minutes to complete" [19]. For our calculations, we took one measurable unit (MU) of LO based e-learning to be an e-learning module that takes 15 minutes of learning time to complete.

To calculate the e-learning project costs, the following assumptions were made:

1. There is only one author involved in the development of a course.
2. If assets and SCOs are accessible to the author, they are available free of cost.
3. The only people involved in creating an e-learning course are listed below:
    a. Author
    b. Instructional designer
    c. Project Manager
    d. Web developer(s)
    e. Media developer (s)
4. The content is measured in terms of ALOs (meta-tagged to form SCOs) and not CLOs.
5. The infrastructure and setup costs for both LO-based and static e-learning projects is assumed to be same.

We concluded,

Cost = f (Time, SkillType)

Where, SkillType = The type of skill required to accomplish a specific task in an e-learning project. E.g. Authoring, Web-development etc.

The cost of the e-learning project is dependent on the type of people involved in the project, the cost for their time, and how much time each spends.

The following variables are considered in the cost analysis:

$C_{NewA[i]}$ = Asset development cost for AssetType A[i] (audio, video, etc.) in one MU of e-learning

$C_{NewAsset}$ = Total cost of modifying and creating new assets e.g. audio, video graphics in one MU of e-learning.

$$C_{NewAsset} = \sum_{i=1}^{n} (C_{NewA[i]} \times F_{ModifyA[i]})$$

Where A[1] = Asset of AssetType "A"

A[2] = Asset of AssetType "B" etc.

n = total number of media elements

C_{Author} = Cost of the Author

C_{PM} = Project management costs

C_{ID} = Instructional design costs

$C_{SCO\text{-}WD}$ = Web development costs for LO-based e-learning project for one MU of e-learning

$C_{Static\text{-}WD}$ = Web development costs for static e-learning project for one MU of e-learning

Note: Due to SCO reuse, we assume $C_{ALO\text{-}WD}$ will be lower than $C_{Static\text{-}WD.}$ The reason for such an assumption is that the content management systems available for LO-based e-learning projects are equipped with authoring tools that automate some of the web development tasks, thereby reducing the work for web developers.

$C_{AssetMData}$ = Cost of meta-tagging and testing for SCORM 1.2. conformance for all new and modified assets in one MU of e-learning

$C_{AssetSearch}$ = Total costs incurred for searching and retrieving assets for one MU of e-learning

$C_{SCOSearch}$ = Costs incurred for searching and retrieving SCOs. These costs could be significantly high as it involves author's time which is usually very costly.

C_{Asset} = Total cost of all assets (new + modified + reused) for one MU of e-learning. It can be calculated from

- $N_{NMAsset}$ = Total number of new and modified assets
- $F_{ModifyM[i]}$ = Media Modification Factor
- $C_{AssetMData}$ = Cost of meta-data tagging new and modified assets

  = $N_{NMAssets}$ x Cost of meta-data tagging one asset

$$C_{Asset} = C_{AssetMData} + \sum_{i=1}^{n} (C_{NewA[i]} \times F_{ModifyA[i]}) + C_{AssetSearch}$$

Similarly for SCOs,

$C_{SCOMData}$ = Total cost of meta-tagging and testing for SCORM 1.2. conformance for all SCOs in one MU of e-learning

C_{SCO} = Cost of all (new + modified + reused) SCOs.

It can be calculated from

- $N_{NM\text{-}SCO}$ = Total number of new and modified SCOs
- $F_{ModifySCO[j]}$ = SCO Modification Factor
- $C_{NewSCO[j]}$ = Development cost for SCO [j]

$$C_{SCO} = C_{SCOMData} + \sum_{j=1}^{m} (C_{NewSCO[j]} \times F_{ModifySCO[j]}) + C_{SCOSearch}$$

if $0 \leq F_{ModifySCO[j]} \leq 1$

$C_{NewContent}$ = Cost of developing new and modified content in the form of assets and SCOs. It does not include the cost of reusing pre-existing assets and/or SCOs as those costs have been taken into account separately.

$N_{AssetReuse}$ = Number of assets reused for creating the course from new and modified assets developed.

$C_{AssetReuse}$ = Costs saved due to reuse of assets. This can be measured from

- $N_{AssetReuse}$ = The Number of assets that are being reused with and without modification.
- N_{Tasset} = Total Number of assets (new + modified + reused).
- $C_{NMAsset}$ = Cost of developing new and modified assets.

By a simple calculation:

$$C_{AssetReuse} = \frac{N_{AssetReuse}}{N_{TAsset}} \times C_{NMAsset}$$

Equation 3.3: Costs saved by Asset reuse

Similarly for SCOs,

$C_{SCOReuse}$ = Costs saved due to reuse of SCOs. This can be measured from

- $N_{SCOReuse}$ = The Number of SCOs that are being reused with and without modification in one MU of e-learning.
- N_{TSCO} = Total Number of SCOs (new + modified + reused).
- $C_{NM\text{-}SCO}$ = Cost of developing new and modified SCOs.

By a simple calculation:

$$C_{SCOReuse} = \frac{N_{SCOReuse}}{N_{TSCO}} \times C_{NM\text{-}SCO}$$

Equation 3.4: Costs saved by SCO reuse

$C_{SaveReuse}$ = Costs saved due to reuse of SCOs and Assets

$C_{NewContent}$ = Sum of all costs involved with developing assets and SCOs.

= $C_{Asset} + C_{SCO} + C_{Author} + C_{PM} + C_{ID} + C_{SCO\text{-}WD}$

$C_{LOProject}$ = Total costs of the LO based e-learning project. This is the difference between $C_{SaveReuse}$ and $C_{NewContent}$

$C_{StaticProject}$ = Total costs of the static e-learning project.

$C_{Difference}$ = Difference in costs between an ALO based e-learning project and static e-learning project.

The cost model is depicted graphically in Figure 3.1 below.

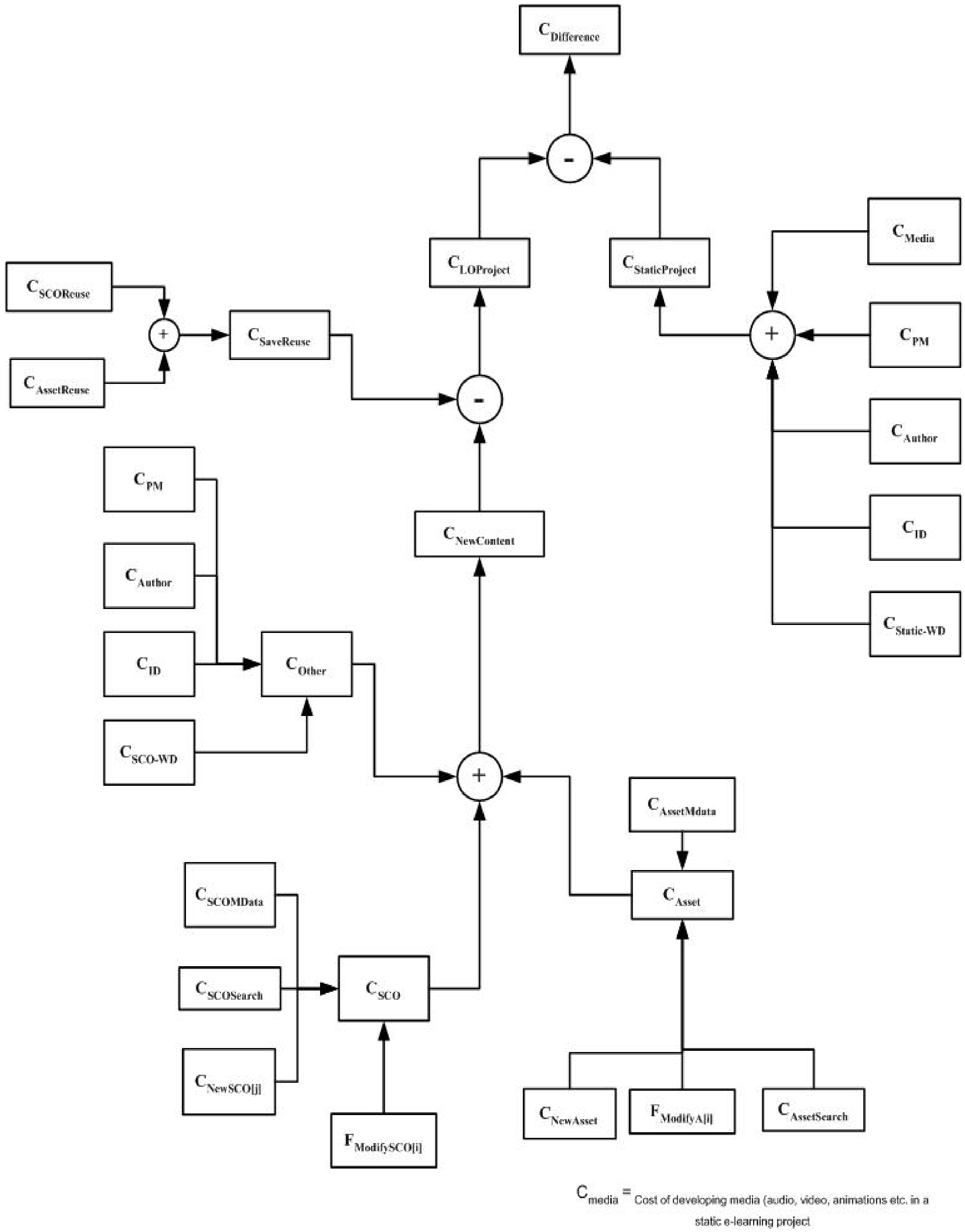

Figure 3.1: Cost model to estimate the difference in e-learning project costs

3.3 Different skills involved in an e-learning project

Table 3.1 Skills and costs associated with an e-learning project

Skill	Costs associated	Presence in LO based e-learning project	Presence in static e-learning project
1. Authoring	C_{Author}	✓	✓
2. Web development	C_{WD}	✓	✓
3. Instructional designing	C_{ID}	✓	✓
4. Meta-tagging	$C_{SCOMData}$ $C_{AssetMData}$	` ✓	✗
5. Project Management	C_{PM}	✓	✓
6. Media development	C_{Media}	✓	✓

Table 3.1 shows the skills and costs associated with a static (non-LO based) and an LO-based e-learning project. “Meta-tagging” is the only extra skill required in an LO based e-learning project that adds to costs, but with reuse, “Authoring” and “Media development” costs can be reduced by SCO reuse and Asset reuse respectively.

3.4 Typical cost values used in E-learning Industry

Following is the data from Harvi Singh, the founder of Mindlever. Mindlever is a pioneering e-learning company in RTP, North Carolina. The numbers have not been verified with studies but they have been used for a large number of e-learning projects in the industry. These numbers are used as rule-of-thumb assumptions by most e-learning companies.

For one MU of e-learning (15 minutes of ALO based e-learning content), the total time for development is approximately 65-70 hours The time division among various personnel is listed in Table 3.2

Table 3.2 Time spent by different types of personnel on AL)-based e-learning project

Type of personnel	Time he/she contributes for 1 MU of e-learning
Author	10 hours
Instructional designer	15 hours
Media Developer	15 hours
Web Developer	15 hours
Meta-tagging costs	2 hours
Project manager	10 hours

3.5 Comparing costs

To compare costs of an LO based e-learning project with a static (non-LO based) e-learning project, we used the numbers from section 3.4, skills-costs adjustment of table 3.1 and the cost estimation formula of figure 3.1.

We now examine the costs of our case study. The costs that were saved by reuse are listed below:

1. Authoring costs due to SCO-level reuse
2. Media Development costs due to asset-level reuse

Because these areas of work were not much affected by any kind of reuse, it was assumed that the costs listed below remained constant in both types of projects:

1. Instructional Design
2. Web development

It was assumed that meta-tagging costs were only added to LO-based e-learning projects and not to static e-learning project because there is no need for meta-tagging in a static e-learning project.

Tables 3.3 to Tables 3.9 lists the time duration of the ALOs in the sample course once they were developed. These numbers are from the author of the course who knows the best how long a topic would take for a learner to learn.

Topic: Pull Production and Kanbans

Table 3.3: Time duration for topic 1

Category	**ALO Unique Identification Number**	**Time Duration (in minutes)**
Category 1	PK-01	15

Category 2	PK-02	20
Category 3	PK-03	25

Topic: Visual Management and Waste Elimination

Table 3.4: Time duration for topic 2

Category	ALO Unique Identification Number	Time Duration (in minutes)
Category 1	VM-01	15
Category 2	VM-02	20
Category 3	VM-03	25

Topic: Cellular Manufacturing

Table 3.5: Time duration for topic 3

Category	ALO Unique Identification Number	Time Duration (in minutes)
Category 1	CM-01	15
Category 2	CM-02	20
Category 3	CM-03	25

Topic: Introduction to Flow Manufacturing

Table 3.6: Time duration for topic 4

Category	ALO Unique Identification Number	Time Duration (in minutes)
Category 1	FM-01	20
Category 2	FM-01	20
Category 3	FM-01	20

Topic: Focused Factories

Table 3.7: Time duration for topic 5

Category	ALO Unique Identification Number	Time Duration (in minutes)
Category 1	FF-01	15
Category 2	FF-01	15
Category 3	FF-01	15

Topic: Pretest

Table 3.8: Time duration for topic 6

Category	ALO Unique Identification Number	Time Duration (in minutes)
Category 1	PRE-01	5
Category 2	PRE-02	5
Category 3	PRE-03	5

Topic: Assessment

Table 3.9: Time duration for topic 7

Category	ALO Unique Identification Number	Time Duration (in minutes)
Category 1	AA-01	5
Category 2	AA-02	5
Category 3	AA-03	5

For our case study,, the following was observed:

1. $C_{AssetSearch}$ = nil, because there was no content repository was available for reuse
2. $C_{SCOSearch}$ = nil, because there was no content repository was available for reuse
3. $F_{ModifiyA[i]}$ = either 0 or 1 because media were not modified. They were either created from scratch or reused without modification.
4. $F_{ModifiySCO[j]}$ = either 0 or 1 because SCOs were not modified. They were either created from scratch or reused without modification.

Considering the above factors,

Total time for all courses for all categories = 310 minutes (from Tables 3.3 through 3.9)

Therefore, number of 15 minute chunks of e-learning = $\frac{310}{15}$

= 20.67

Table 3.10: Distribution of time for static e-learning course

Type of personnel	Time he/she contributes for 15 minutes of output of e-learning	Total time for the sample course (in hours) (Time x 20.67)
Author	10 hours	206.7
Instructional designer	15 hours	310
Media Developer	15 hours	310
Web Developer	15 hours	310
Meta-tagging costs	NA	NA
Project manager	10 hours	206.7
	TOTAL	**1384.74**

Table 3.10 explains the distribution of development time among various people that would be involved in the static e-learning project. Similarly, Table 3.11 explains the distribution of development time among various people that would be involved in the LO based e-learning project. It also calculates the time savings due to SCO level reuse and asset level reuse and subtracts that from the appropriate personnel's development time.

Table 3.11: Distribution of time for LO based e-learning course

Type of personnel	**Time he/she contributes for 15 minutes of output of e-learning (hours)**	**Total time for the sample course (in hours) (Time x 20.67)**	**Reuse percentage applicability (%)**	**Time after saving by reuse i.e. $\text{Total time} - (\frac{\text{percent reuse}}{100} \times \text{Total time}$ (hours)**
Author	10	206.7	19 (SCO reuse)	167.43
Instructional designer	15	310	NA	310
Media Developer	15	310	57 (Asset reuse)	133.33
Web Developer	15	310	NA	310
Meta-tagging costs	2	41.34	NA	41.34
Project manager	10	206.7	NA	206.7
			TOTAL	**1168.8**

Time saved = 1384.74 - 1168.8

= 215.94

= **216 hours (approx.)**

Percentage of project-time saved = $\frac{\text{Time saved}}{\text{Total time for static e - learning project}} \times 100$

= $\frac{215.94}{1384.74} \times 100$

= **15.6% (approx)**

Total cost difference ($C_{Difference}$) between a static e-learning project and an LO-based e-learning project are the costs of:

1. T_{Author} = Saving of author's time (due to reuse)
2. T_{Media} = Savings of media developer's time (due to reuse)

$C_{Difference} = (C_{Author} \times T_{Author}) + (C_{Media} \times T_{Media})$

We are not assuming the costs per hour of the author or the media developer. But these are usually two of the highest costs involved in the project. So it can be seen that the costs saved by LOs are too high to be ignored by an organization.

It is also to be noted that the sample course was developed without the presence of a content repository. That means that no pre-existing ALOs or assets were available. Once a content repository is available (which keeps growing as more and more ALOs and assets are developed), the percentage of reuse is expected to grow dramatically and hence cost savings.

4 Conclusions and Future Research

An ALO based e-learning course was developed for an industrial enterprise to develop a model for e-learning that organizations can deploy. Following hypotheses were tested:

- An e-learning model can be developed which both achieves its instructional design requirements and conforms to industry standards.
- Utilizing an LO-based e-learning model can reduce project costs and make e-learning more affordable for organizations.

The result was an e-learning model that started from employing an instructional design strategy, creating reusable ALOs, CLOs and assets, and finally linking the reusable content to the skills that need to be acquired by the employees in the organization. Ultimately, the content was deployed with SCORM 1.2 meta-data compliance and with customization. Cost analysis demonstrated an overall project cost savings of 16% based on reuse Future research on this topic should focus on:

- Measuring how reuse of ALOs increases with an increasing number of ALOs in the content repository of the organization.
- Collecting and analyzing more data on development time and costs to improve on the cost measurement technique
- Measuring the instructional effectiveness of ALO-based e-learning course vs. non-ALO based e-learning course based on student learning
- Customizing ALO based e-learning courses to the learning style of the learner.

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6 Appendices

1. Appendix A: ABB manufacturing training needs table
2. Appendix B: Glossary
3. Appendix C: Sharable Content Object Reference Model (SCORM) version 1.2
4. Appendix D: Modified SCORM version 1.2 meta-data tags table for the e-learning model.
5. Appendix D: Sample meta-data XML file
6. Appendix E: Flowchart explaining e-learning model behavior
7. Appendix F: Screen shots of the sample course developed

6.1 Appendix A:

Table 2: ABB manufacturing training needs table

Organization Level	Front-end	Engineering (Design)	Supply Management	Production Planning	Manufacturing	Shipping	After Sales
BA-Division Management	ABC/M, Front End Systems, Lean Manufacturing, Focused Factory, Manufacturing strategy&Management	Concurrent Engineering, Mass customization, Focuseded Factory, Lean Manufacturing, Manufaturing Strategy&Management, Economic Analy., Delayed Differentation	Supply Chain Management, Lean Manufacturing, Focused Factory, Manufacturring Strategy&Management, TOC	Focused Factory, Lean Manufacturing Strategy&Management, Supply Chain Management, TOC	Focused Factory, Lean Manufacturing, Manufacturing Strategy&Management, ERP, Quality, TOC	Focused Factory,Lean Manufacturing, Logistics	Focused Factory, Lean Manufacturing, Service, Refurbishement
BAU Management	ABC/M, Focused factory, ABB Gate model, Lean Manufacturing, Front End Systems	Concurrent Engineering, Economic analysis, Mass customization, Focused Factory, Lean Manufacturing, Delayed Differentiation, Six Sigma	Supply Chain Management, Lean Manufacturing, Focused Factory, Manufacturing Strategy&Management, TOC	ERP, Focused Factory, Lean Manufacturing, Manufacturing Strategy&Management, Supply Chain Management, TOC	Lean Manufacturing, Focused Factory, Manufacturing Strategy&management, Automation, TOC, Quality	Focused Factory, Lean Manufacturing. Logistics	Focused Factory, Lean Manufacturing, Refurb., Service, Teaming, Conflict Mgmt.
Engineers & Supervisors	Project Mgmt., ABB Gate model, Focused factory, Teaming, Front End Systems	Concurrent Engineering, Economic analysis, Reliability, Robustness, Mass customization, Delayed Diff., Six Sigma,	Kanban, Supply Chain Systems, TOC	Scheduling, APS, JIT Production&Inventory Control, TOC	Lean Manufacturing,TOC, Focused Factory, Manufacturing Strategy&, Automation, Quality, Supply Chain Mgmt, Finance, Teaming, Simulation	Logistics, JIT Production&Inventory Control	Service, Refurbishment
Production Associates (Hourly)	Quality, Teaming,	Six Sigma	Kanban, JIT Production&Inventory Control, 5S	Scheduling	Focused Factories, Quality, Lean Manufacturing, Maintenance, Teaming, Conflict Mgmt.	Kanban, 5S	

6.2 Appendix B: Glossary

1. Author: The person who compiles the subject matter/content to be presented in the ALO/CLO
2. ALO$^{\text{SM}}$: “Atomic Learning Object” refers to a learning resource which has one and only one learning objective. As an example, a topic inside a chapter which cannot be granularized further into smaller ALOs.
3. CLO$^{\text{SM}}$: “Composite Learning Object” is a collection of two or more ALOs and/or other CLOs. As an example, a chapter with several topics (ALOs) can be considered as a CLO. Another example could be a Course consisting of Chapters (CLOs) which further consists of Topics (ALOs).
4. SCORM$^{\text{TM}}$: “Sharable Content Object Reference Model” is a specification model for standardization of e-learning conceived by Advanced Distributed Learning initiative.
5. Asset: Assets are electronic representations of media, text, images, sound, web pages, assessment objects or other pieces of data that can be delivered to a Web client.
6. SCO: A “Sharable Content Object” represents a collection of one or more Assets that include a specific launchable asset that utilizes SCORM Run-Time Environment to communicate with Learning Management Systems (LMSs). In other words, an SCO is an ALO or a CLO tagged with meta-data to make it SCORM 1.2 compliant.

7. LMS: “Learning Management System” refers to a suite of functionalities designed to deliver, track, report on and manage learning content, student progress and student interactions (SCORM version 1.2)
8. LCMS: “Learning Content Management System”
9. Instructional Design: Instructional Design is the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. It is the entire process of analysis of learning needs and goals and the development of a delivery system to meet those needs
10. Job Function: Skills and functions that an employee has to know for his job.
11. Unique Identifier: A unique number that identifies a resource e.g. SCOs and Assets.
12. Content: The subject matter that a learner is meant to learn provided by an ALO or a CLO.
13. Pretest: A quiz that a learner takes before he studies the content provided in an ALO or a CLO.
14. Assessment: The quiz that a learner takes after he/she learns the content provided by the ALO or the CLO to determine the degree to which he/she has learnt the content.
15. Content repository:
16. Resource: is a term refereeing to any learning entity e.g. asset. SCO etc.

6.3 Appendix C: Sharable Content Object Reference Model (SCORM) Version 1.2

This document is an introduction to SCORM version 1.2 [2]. It provides just enough overview of SCORM to help reader understand the concepts used for this research. Detailed document for understanding SCORM can be obtained from the Advanced Distributed Learning official website: www.adlnet.org.

6.3.1 Introduction

The Department of Defense (DoD) established the Advanced Distributed Learning (ADL) initiative in 1997 to modernize education and training and to develop e-learning standardization. ADL defines SCORM as "The Sharable Content Object Reference Model (SCORM) defines a Web-based learning Content Aggregation Model and Run-time Environment for learning objects." [2]

SCORM was started out with the following goals in mind:

1. **Accessibility**: the ability to access instructional modules from any location
2. **Interoperability**: the ability to develop instructional modules at any location and to use them at another location on a different platform thus making them platform independent.
3. **Durability**: the ability to withstand technological changes without redesign, configuration and recoding.
4. **Reusability**: the flexibility to incorporate instructional modules in multiple applications and contexts.

6.3.2 The SCORM Content Aggregation Model

The SCORM Content Aggregation Model provides means to aggregate learning resources for the purpose of delivery. It involves creating, developing and gathering content and then organizing them in a desired sequence for delivery. Keeping this in mind, the SCORM Content Aggregation Model is made up of the following:

Content model: Nomenclature defining the content components of a learning experience.

Meta-data: A mechanism for describing specific instances of the components of the content model.

Content Packaging: Defines how to package learning resources for movement between different environments.

The SCORM Content Model Components

Assets: Assets are electronic representations of media, text, images, sound, web pages, assessment objects or other pieces of data that can be delivered to a Web client.

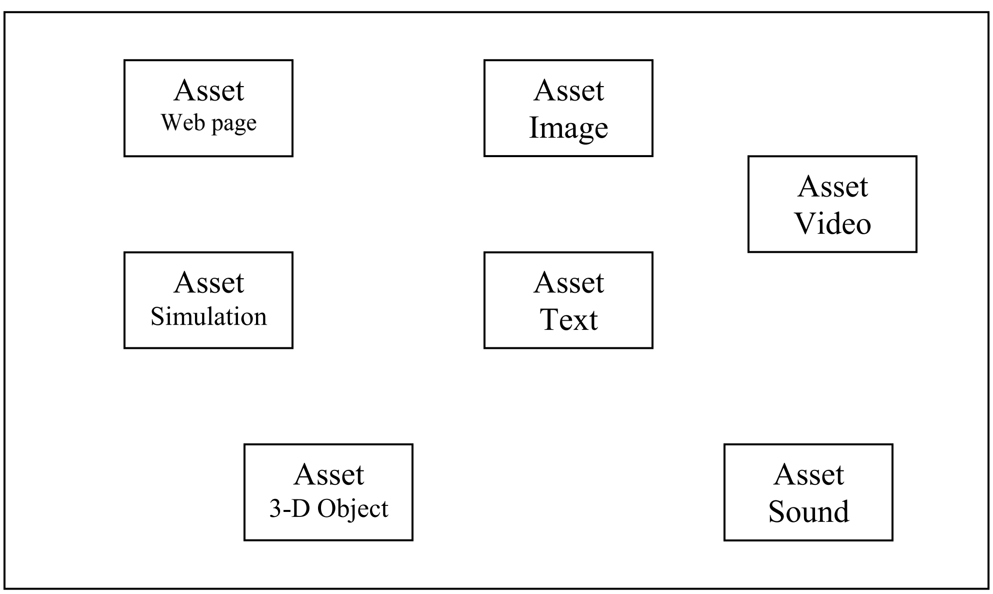

Figure 1: Asset Examples

An asset can be described using Asset meta-data to be called Content Packaging.

Sharable Content Object (SCO)

A Sharable Content Object (SCO) represents a collection of one or more assets that include a specific launchable asset that utilizes SCORM Run-Time Environment to communicate with Learning Management Systems (LMSs).

Note: Launching an asset means that there is a meta-data file associated with that asset that is parsed by the LMS and the meta-data values used by the LMS to run the asset.

An SCO is an equivalent of an ALO or a CLO. SCO is the smallest learning resource that can be tracked by an LMS using the SCORM Run-Time Environment. For an SCO to be reusable, it has to be independent of the learning context. For example, in the "Flow Manufacturing" course developed of this research, module "Cellular Manufacturing" is independent in itself i.e. it can be used in some other course as well without any modifications.

A SCO can be described with SCO meta-data to allow for search and discovery within repositories, thereby enhancing opportunities for reuse. This mechanism as explained later is called Content Packaging. SCORM also states that an SCO can only be invoked by an LMS and not by another SCO.

6.3.3 The SCORM Meta-data Information Model

The SCORM meta-data Information Model describes the data elements that are defined to build SCORM conformant meta-data records. There are nine major categories defined by the SCORM Information Model:

1. General
2. Lifecycle

3. Meta-metadata
4. Technical
5. Educational
6. Rights
7. Relation
8. Annotation
9. Classification

6.3.4 Content Packaging

Content Packaging provides a standardized way to exchange learning resources between different systems and tools. Content Packaging can also define the structure of learning resources. Content Packaging defines a Manifest file which has elements like Meta-data about the package, an "Organization" section that defines content structure, how to create XML-based Manifest and directions for packaging the Manifest into a zip file or CD-ROM, etc.

6.3.5 The SCORM Run-Time Environment

SCORM defines three aspects of Run-Time Environment:

1. Launch
2. Application Program Interface (API)
3. Data model

The *Launch* mechanism defines a common way for LMSs to start Web-based learning resources. It is the responsibility of the LMS to determine which learning resource is to be launched.

The API is the communication mechanism for informing the LMS of the state of the learning resource, e.g. initialized, finished or in an error condition. API is also used for getting and setting data between the LMS and the SCO. The functions of the API are exposed by a piece of software called the API adapter. SCORM defines three basic functions of the API adapter:

1. Execution State: API functions to start and finish an SCO.
2. State management: API functions used to handle errors.
3. Data transfer: API functions used to transfer data to and from an LMS.

The Data Model is a standard set of data elements used to define the information being communicated. The SCORM Run-Time Environment Data Model is directly derived from the AICC CMI Data Model described in the AICC CMI Guidelines for Interoperability (site reference). There are a set of general usage rules defined by SCORM for the Data Model.

6.4 Appendix D: Modified SCORM version 1.2 meta-data tags table for the e-learning model

This table is a modified version of The SCORM 1.2 Content Aggregation Model

Table 3: Complete list of SCORM 1.2 Content Aggregation meta-data tags

Name	Content Aggregation	SCO	Asset
1.0 general	M	M	M
1.1 identifier	R	R	R
1.2 title	M	M	M
1.3 catalogentry	M	M	O
1.3.1 catalog	M	M	O
1.3.2 entry	M	M	O
1.4 language	O	O	O
1.5 description	M	M	M
1.6 keyword	M	M	O
1.7 coverage	O	O	O
1.8 structure	O	O	O
1.9 aggregationlevel	O	O	O
2.0 lifecycle	M	M	O
2.1 version	M	M	O
2.2 status	M	M	O
2.3 contribute	O	O	O
2.3.1 role	O	O	O
2.3.2 centity	O	O	O
2.3.3 date	O	O	O
3.0 metametadata	M	M	M
3.1 identifier	R	R	R
3.2 catalogentry	O	O	O
3.2.1 catalog	O	O	O

Table 3 continued

3.2.2 entry	O	O	O
3.3 contribute	O	O	O
3.3.1 role	O	O	O
3.3.2 centity	O	O	O
3.3.3 date	O	O	O
3.4 metadatascheme	M	M	M
3.5 language	O	O	O
4.0 technical	M	M	M
4.1 format	M	M	M
4.2 size	O	O	O
4.3 location	M	M	M
4.4 requirement	O	O	O
4.4.1 type	O	O	O
4.4.2 name	O	O	O
4.4.3 minimumversion	O	O	O
4.4.4 maximumversion	O	O	O
4.5 installationremarks	O	O	O
4.6 otherplatformrequirements	O	O	O
4.7 duration	O	O	O
5.0 educational	O	O	O
5.1 interactivitytype	O	O	O
5.2 learningresourcetype	O ***(M)***	O ***(M)***	O
5.3 interactivitylevel	O	O	O
5.2.2 entry	O	O	O
5.3 contribute	O	O	O

Table 3 continued

5.4 semanticdensity	O	O	O
5.5 intendedenduserrole	O	O	O
5.6 context	O ***(M)***	O ***(M)***	O
5.7 typicalagerange	O	O	O
5.8 difficulty	O	O	O
5.9 typicallearningtime	O	O	O
5.10 description	O	O	O
5.11 language	O	O	O
6.0 rights	M	M	M
6.1 cost	M	M	M
6.2 copyrightsandotherrestrictions	M	M	M
6.3 description	O	O	O
7.0 relation	O ***(M)***	O ***(M)***	O
7.1 kind	O	O	O
7.2 resource	O	O	O
7.2.1 identifier	R	R	R
7.2.2 description	O	O	O
7.2.3 catalogentry	O	O	O
7.2.3.1 catalog	O	O	O
7.2.3.2 entry	O	O	O

6.5 Sample XML meta-data file

All meta-data XML files pass:

- SCORM 1.2 Content Aggregation schema validation test
- SCORM 1.2 Content Aggregation conformance test (provided in SCORM 1.2 test suite software package)
- E-learning model schema validation test

Here is a sample meta-data file that tags the SCO named CM-01. It has all the mandatory tags that the e-learning model expects.


```
  <?xml version="1.0" encoding="UTF-8" ?>
- <lom xmlns="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1
   C:\DOCUME~1\banga\Desktop\imsmd_rootv1p2p1_new1.xsd">
- <general>
- <title>
  <langstring>Cellular Manufacturing for Top-Managers</langstring>
  </title>
- <catalogentry>
  <catalog>ABB courses catalog</catalog>
+ <entry>
  </catalogentry>
  <language>en</language>
- <description>
  <langstring>A 15- minute learning module about Cellular Manufacturing for
   Top-Managers</langstring>
  </description>
+ <keyword>
- <keyword>
  <langstring>Cellular</langstring>
  </keyword>
+ <keyword>
  </general>
- <lifecycle>
- <version>
  <langstring>1.0</langstring>
  </version>
- <status>
+ <source>
- <value>
```

<langstring xml:lang="**x-none**">**Final**</langstring>
</value>
</status>
- <contribute>
- <role>
+ <source>
- <value>
<langstring xml:lang="**x-none**">**Author**</langstring>
</value>
</role>
- <date>
<datetime>**2002-02-27**</datetime>
</date>
</contribute>
</lifecycle>
- <metametadata>
<metadatascheme>**ADL SCORM 1.2**</metadatascheme>
</metametadata>
- <technical>
<format>**HTML**</format>
<size>**2855**</size>
<location>**SCOs/CM-01.htm**</location>
- <requirement>
- <type>
+ <source>
- <value>
<langstring xml:lang="**x-none**">**Browser**</langstring>
</value>
</type>
- <name>
+ <source>
- <value>
<langstring xml:lang="**x-none**">**Microsoft Internet Explorer**</langstring>
</value>
</name>
<minimumversion>**5.0**</minimumversion>
</requirement>
</technical>
- <educational>
- <learningresourcetype>
- <source>
<langstring xml:lang="**x-none**">**ADL**</langstring>
</source>
- <value>
<langstring xml:lang="**x-none**">**Content**</langstring>
</value>
</learningresourcetype>
- <context>
+ <source>

```
- <value>
  <langstring xml:lang="x-none">Technical Level One</langstring>
    </value>
    </context>
    </educational>
- <rights>
- <cost>
+ <source>
- <value>
  <langstring xml:lang="x-none">no</langstring>
    </value>
    </cost>
- <copyrightandotherrestrictions>
+ <source>
- <value>
  <langstring xml:lang="x-none">yes</langstring>
    </value>
    </copyrightandotherrestrictions>
    </rights>
- <relation>
- <kind>
+ <source>
- <value>
  <langstring xml:lang="x-none">HasPretest</langstring>
    </value>
    </kind>
- <resource>
- <description>
  <langstring xml:lang="en">PRE-01.htm</langstring>
    </description>
    </resource>
    </relation>
- <classification>
- <purpose>
- <source>
  <langstring xml:lang="x-none">ADL</langstring>
    </source>
- <value>
  <langstring xml:lang="x-none">Technical Level</langstring>
    </value>
    </purpose>
+ <description>
+ <keyword>
    </classification>
  </lom>
```

6.6 Flowchart explaining e-learning model behavior

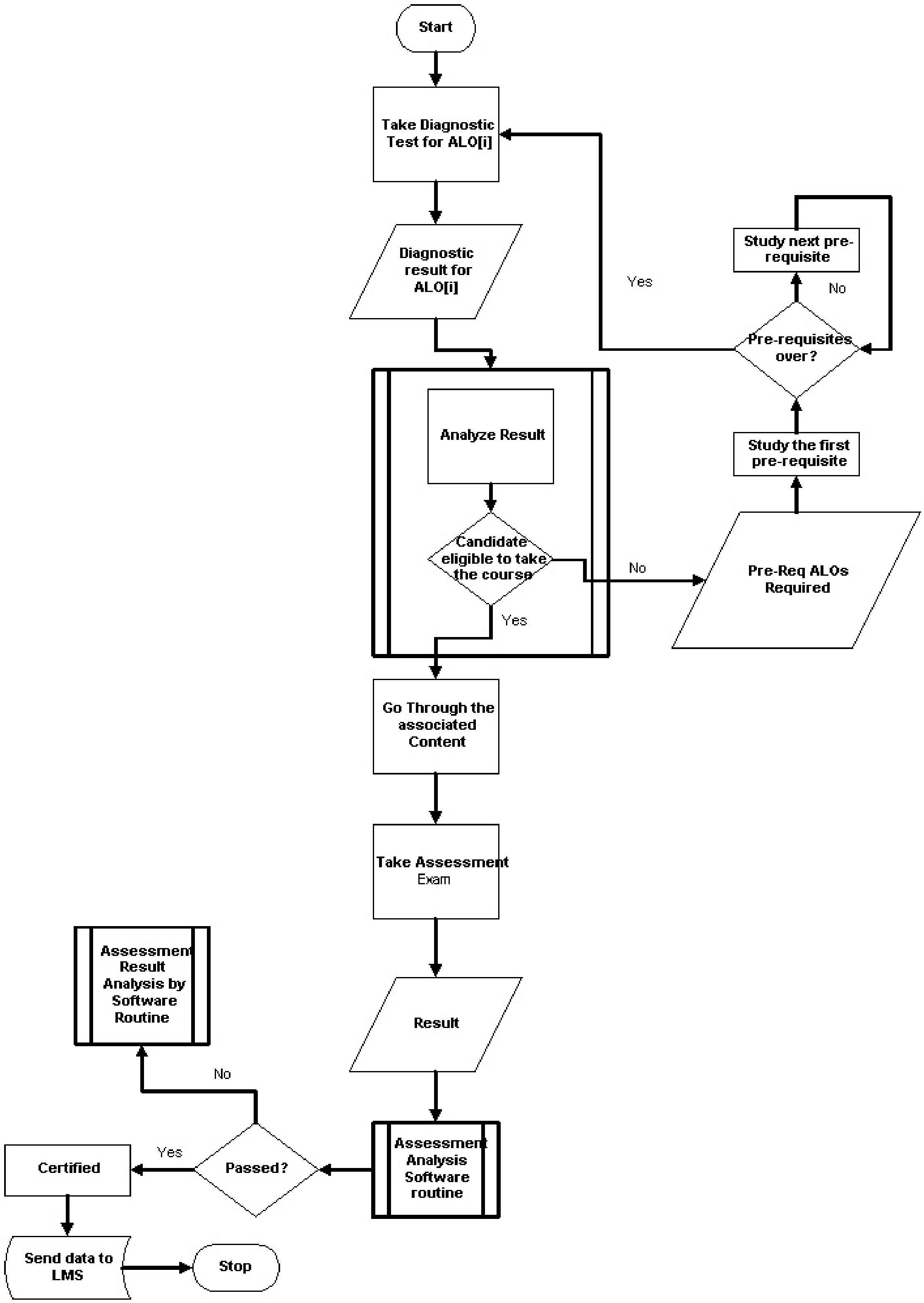

Figure 2: Flowchart explaining system behavior

6.7 Appendix F: Screen shots of the sample course developed

Course Name: Flow Manufacturing

Topics:

1. Pretest
2. Pull Production and Kanbans
3. Visual Management and Waste Elimination
4. Cellular Manufacturing
5. Introduction to Flow Manufacturing
6. Focused Factories
7. Assessment

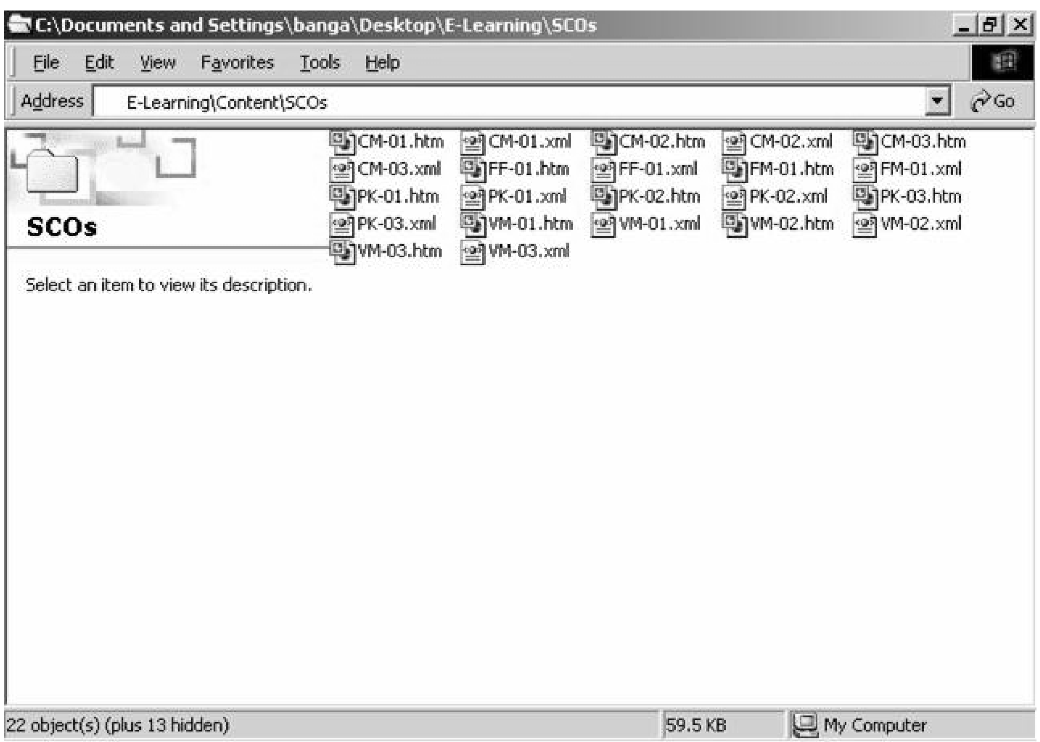

Figure 3: Screen shot describing how the LOs are stored

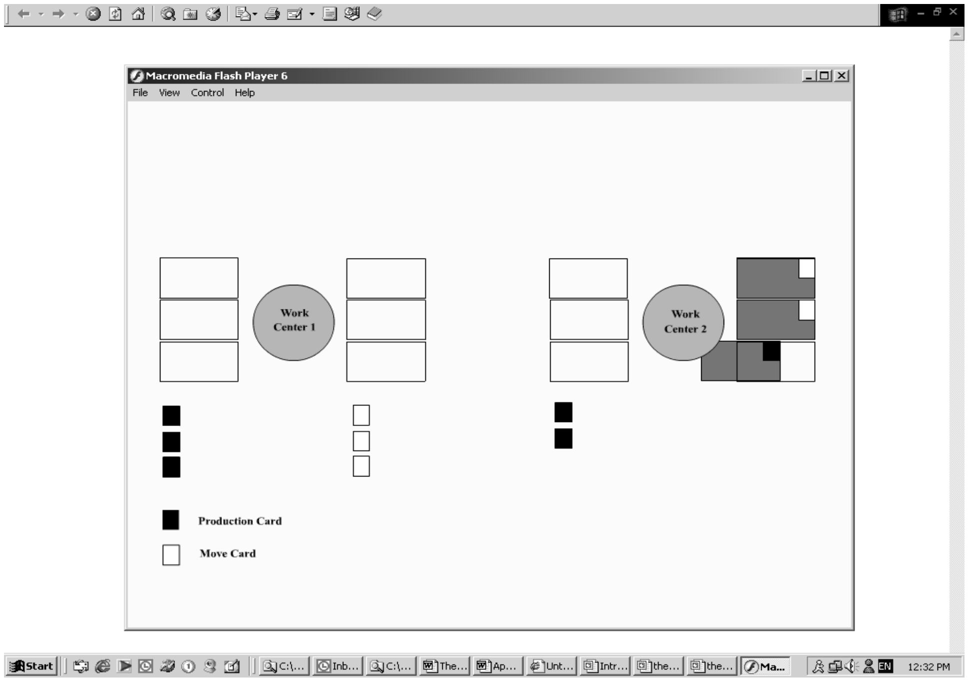

Figure 4: Screen shot showing an animation Asset

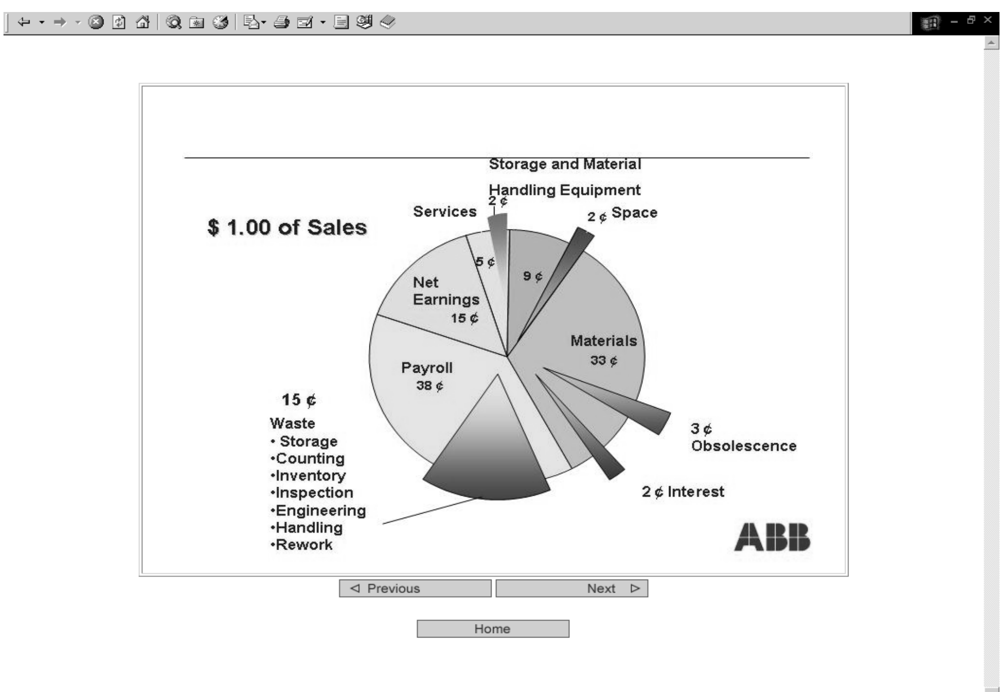

Figure 5: Screen shot showing an ALO at work

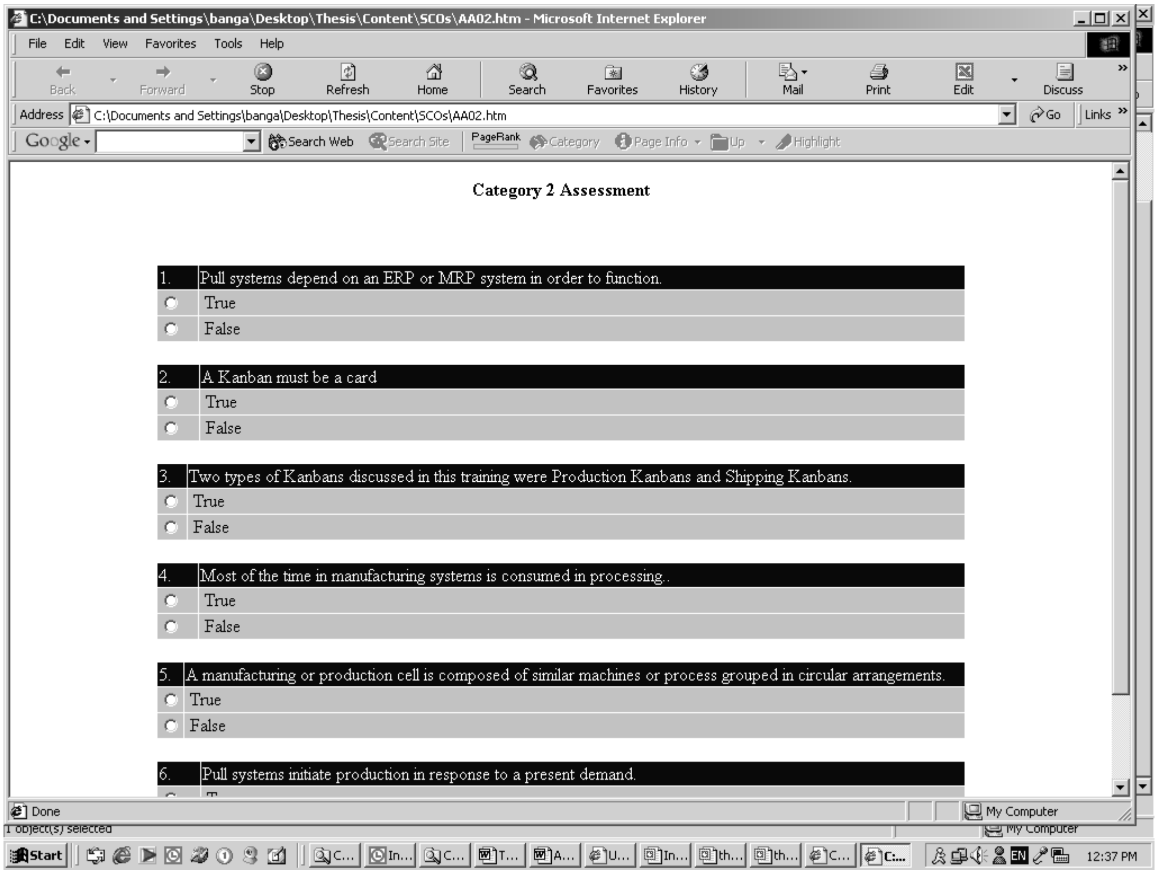

Figure 6: Screen shot showing a assessment ALO