ASSESSING SCORM 2004 FOR ITS AFFORDANCES IN FACILITATING A SIMULATION AS A PEDAGOGICAL MODEL

by

Patrick Shane Gallagher
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
in Education

Committee:

Priscilla Norton ______ Chair

______

______

______ Program Director

______ Dean, College of Education and Human Development

Date: 12/6/07 ______

Fall Semester 2007
George Mason University
Fairfax, VA

Assessing SCORM 2004 for its Affordances in Facilitating a Simulation as a Pedagogical Model

A dissertation is submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

By

Patrick Shane Gallagher
Master of Arts
University of New Mexico, 1998

Director: Dr. Priscilla Norton
Dr. Eamonn Kelly
Dr. Brenda Bannan-Ritland
College of Education and Human Development

Fall Semester 2007
George Mason University
Fairfax, VA

DEDICATION

This dissertation is dedicated

To my wife Catherine for her undying support, faith, and many sacrifices in seeing this through,

To my children Bhaktivinode, Siromani, Sundari, Ian, and Aaron for their support and many sacrifices along the way,

To my brother Sid whose encouragement and initial support allowed me to begin this venture and who has never been far away,

To my sister Lisa for her belief and enthusiasm that I would could do this,

And, finally to my parents Golden and Vio who led me to believe that I could do anything I set my mind to and, too, have never been far away.

ACKNOWLEDGEMENTS

First, I would like to thank my committee chair, Dr. Priscilla Norton. I began this journey with her in New Mexico and ended up finishing with her in Virginia. She has been an inspiration, excellent teacher, and friend. Through my work with Dr. Norton, I began to truly see what education means and to begin the journey towards understanding. This dissertation would not have been finished without her mentorship, encouragement, and belief.

Next, I would like to thank my committee members Dr. Brenda Bannan-Ritland and Dr. Eamonn Kelly. Dr. Bannan-Ritland has provided the educational foundation in instructional design and support that made possible for me to progress to this point. Dr. Kelly through many classes, seminars, symposia, and meetings at coffee shops has thoroughly warped my thinking. In fact, Dr. Kelly, it is truly the time to go out under stars in the desert night air of the southwest and...

I would also like to thank my colleagues at SAIC for their longtime support and help. In particular, I would like to thank Heidi Henderson for helping me to think through ideas, complete support, "logistical planning," and encouragement. It has truly made the difference. I would also like to thank Hasan Altalib for allowing me to bounce ideas off of him, keep my schedule open, and work through the final requirements that became the SIMREF.

Next I would like to thank Paul Jesukiewicz for his support and the support of ADL, Angelo Panar for his knowledge and time, Jean Burmester for her support from the Joint ADL Co-lab, and Dr. Judy Brown for her support and help from the adlcommunity.org.

Finally, I would like to thank my family, wife Cathy for her love and support and my two youngest children Ian and Aaron for being so understanding when I was pursuing this degree as they were moving through middle school, through high school, and onto

college – I know it wasn't easy on any of you but I love and appreciate all of you very much including and not forgotten Bhaktivinode, Siromani, and Sundari (you just weren't at home).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

ASSESSING SCORM 2004 FOR ITS AFFORDANCES IN FACILITATING A SIMULATION AS A PEDAGOGICAL MODEL

Patrick Shane Gallagher Ph. D.

George Mason University, 2007

Dissertation Director: Dr. Priscilla Norton

This study assessed SCORM 2004 for its affordances facilitating the implementation of specific requirements representing a simulation-based model optimized for interoperability and reusability. The overarching assessment methodology consisted of a gap analysis. A specific set of requirements called the Simulations Requirements Framework (SIMREF) derived from an existing online simulation learning environment was developed as the criterion and the Run-time Environment (RTE) and Sequencing of the SCORM 2004 technical architecture were targeted as the condition. To achieve the gap analysis, 26 experienced SCORM developers employed in industry, government, standards/specifications entities, and academia were surveyed.

Participants were asked to provide levels of agreement to indicator statements of the relevance of the SCORM 2004 technical architecture targets to the SIMREF requirements at both the individual and set levels. As such, data were collected and analyzed to determine the relevance of SCOs, functional or typed SCOs, extending

SCORM 2004, extending Sequencing, relevance of SCO to SCO data sharing, and the utilization of a LMS thick client. Participants were also asked to describe alternate standards, specifications, technologies, and capabilities necessary to fulfill the requirements.

The findings from the data analyses indicated that according to the SCORM development community gaps do exist in the implementation of the SIMREF with respect to SCORM 2004 technical architecture as well as in common implementation practice. These gaps occurred within the communication affordances in the RTE and in the data value/variable management and if-then logic within Sequencing. Gaps are also present in the common implementation practice of using SCOs purely for content presentation. One prominent implication is the need for persistent arbitrary SCO to SCO communication which could be accomplished through the inclusion of the IMS SSP specification. Also implied, are gaps in the field of instructional design in relation to designing SCORM-based solutions as well as gaps in the understanding of IT engineers and practitioners in relation to learning theories and practices. In respect to SCORM 2004 and simulations as a pedagogical model to produce more meaningful learning, the underlying behaviorist pedagogy inherent in its design needs to be revisited and in so doing the academic community needs to become more involved in its evolution.

1. Introduction

Overview

As online learning is increasingly becoming a preferred alternative to face to face instruction with over 90% of universities engaged in some form of online learning and most corporations now regarding online learning as a necessary strategy (Jonassen & Churchill, 2004), major trends have begun to emerge (Gallagher, 2002). These trends center on the convergence of technologies and the blending of and transitioning from old to new instructional and instructional design paradigms. They also exist beyond traditional organizational boundaries crossing the line between private and public, corporate and the military.

These changes have brought with them many pedagogical opportunities, considerations, and challenges and have created the need for instructional designers to be aware of the design implications associated with new and emerging online learning systems (Shank, 2001). In this environment, instructional design is being re-evaluated, and new models of design are being sought (Sims, 1997). One prominent challenge occurring in instructional design as a result of online learning is the selection and application of instructional strategies to achieve higher order learning outcomes. As epistemologies have shifted from behaviorism to cognitivism and constructivism, building blocks typically used for online instruction begin to fall short as they typically support lower level outcomes and a behaviorist or objectivist view of learning.

Ubiquitous among these online learning building blocks are micro instructional units or objects call learning objects (LOs). Because the definition of a learning object as defined by the Institute of Electrical and Electronics Engineers (IEEE) is broad and excludes virtually nothing as a learning object, multiple organizations and entities have defined a learning object according to their own specifications (Institute of Electrical and Electronic Engineers Learning Technology Standards Committee [IEEE LTSC], 2002; L'Allier, 1997; Wiley, 2001). As a result, there is no standardization or even a standard definition of what constitutes a learning object resulting in customized learning content operable in a single learning environment with little or no reuse of the learning content. This situation is a direct impediment to the abilities of web-based learning environments in exploiting content repositories to ensure lower development costs and lower delivery costs due to content reuse and system interoperability.

Some communities are beginning to standardize learning object characteristics, usages, and reusability through what is called a learning object content model (LOCM). It is through the affordances presented by these LOCMs that higher order learning outcomes can be facilitated. However, the type of affordances present are actually seen as a drawback in incorporating pedagogical models that more robustly facilitate meaningful learning (Jonassen & Churchill, 2004).

Background

As technology and specifically Internet and Web technology (also called Information and Communication Technology or ICT) becomes entrenched in education and training activities, it is being viewed as a tool to support learning in a variety of learning experiences from formal self-directed autonomous courses to virtual classrooms

(Korea Education & Research Information Service [KERIS], 2003) to the informal instantiated in search and discovery, simulations, and electronic performance support systems (EPSS). ICT tools are also being aggregated as knowledge management and e-learning are converging into meta- systems supporting formal learning, informal learning, learning communities, and communities of practice. These meta-systems are also merging human resource management with online learning in career tracking as well as competency management directly tying course credits and certifications to career paths.

Shifting epistemologies and the quest for more meaningful online learning have defined learner-centric design as an overarching tenet. Supporting this shift, the convergences of ICT-based knowledge management and e-learning systems are providing more learner control. New types of interactions and learning experiences will have to be considered and developed according to capabilities offered by the technology. This will require new approaches and techniques to bring technology use to its full potential (Gallagher, 2002). Although there are several approaches and models currently being considered and/or used successfully in an online environment, in the corporate and government training arena and especially within the Department of Defense (DoD) (Menaker, Coleman, Collins, & Murawski, 2006), the approach gaining more and more prominence is that of the simulation.

Simulation Overview

In education, simulations have come to encompass children's simulation-games, curricula based on student modeling, lab simulations for science study to commercial and expensive flight simulators for teaching airline pilots how to fly. They have also come to encompass large networked simulations for military battlefield training, virtual reality, microworlds, and goal-based scenarios. In other words, the definition is at once all-encompassing or specific depending on who is creating the definition. According to Alessi, an educational simulation is a program that incorporates a learner-manipulated model accompanied with a learning objective that includes understanding the model (Alessi, 2000).

Educational simulations are considered important tools to support learning both in the literature and by scientists and practitioners. Yet, there exists confusion over scope and definition usually due to terminology. The same type of simulation often is described by many terms. For example, *microworld, management flight simulator, business simulator, business game, management simulator,* and *learning environment* are all terms that sometimes describe the same kind of simulation. Also, two simulations having the same name may be very distinct in functionality and type (Maier & Grobler, 2000).

Diversity in terms illustrates the diversity in purposes surrounding the development and deployment of simulations in the learning context. Such purposes include learning to be a better manager, learning how to perform and function with a team (e.g. medical or flight), understanding systems through exploration (e.g. virtual labs or models) and virtually any discipline where application and higher order learning are important. Simulations can allow the engineer/scientist to modify a system and then test that against a known set of inputs or provide a system that can be used to support various modeling and simulation domains. Simulations can facilitate training by immersing a learner in a virtual environment that is too costly or dangerous to allow in reality such as toxic environments or high-fidelity flight simulators.

When targeted towards learning, well-designed simulations can have a high level of learning transference ideal in education and training. Transference is considered the ability of a learner to apply what has been learned in a learning situation quickly and effectively to other real-life situations (Driscoll, 2000). This characteristic enhances the desirability of not only using but reusing simulations on a broad scale. However, as simulations are usually very contextual in both design and implementation, such reuse would not only require reusable designs but the use of standardized interoperable platforms such as standards conformant learning management systems (LMS) integrated with a LOCM based upon widely agreed upon specifications and standards.

Learning Technology Standards

For learning experiences to be managed, tracked, and reusable, they must be standardized in the way they are described and implemented (Strijker, 2004; Sutcliffe, 2002). For reuse to occur across multiple organizations and enterprise systems, this standardization is based upon defined specifications and standards published by existing bodies such as the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE), the Instructional Management Systems (IMS) Global Learning Consortium, the IEEE Learning Technology Standards Committee (LTSC), or the Dublin CORE (Duval, 2004; Wiley, 2001).

Specifications are developed by organizations such as the IMS or the Aviation Industry Computer-based Training (CBT) Committee (AICC) which may or may not feed into existing or upcoming standards. Existing standards organizations may work with specifications bodies and/or implementers (industry) to develop and recommend specifications to higher standards organizations for new standards. Specific implementations or LOCMs may be an implementation of one or more standards or specifications, a unique model, or some combination of standards, specifications, and models. As an example of this fuzzy delimitation, IMS LO metadata is a specification which has become the basis for the IEEE Learning Object Metadata (LOM) standard but is also used in its entirety as a basis for specific LOCMs or specific implementations of the complete specification. The Shareable Content Object Reference Model (SCORM), developed by the DoD Advanced Distributed Learning (ADL) initiative, is a hybrid of standards and specifications pulling from IEEE, IMS, and AICC with a defined implementation strategy or application profile. A LOCM concerned with the overarching issues of reuse and interoperability then may be based entirely or in part upon these standards and/or specifications.

In looking at the characteristics of the prominent standards-based LOCMs existing across industry and government, it is apparent that there is not much difference in their structure, specifications and the underlying pedagogical model and paradigm that they are based upon. In fact, they all fit within the superset of attributes described by Verbert and Duval (2004) as their General Learning Object Content Model created for analysis. The analysis compared several defined LOCMs and discussed this fit as the LOCM homogeneity and basis of LO interoperability and reusability across systems.

SCORM is closely related to the other LOCMs prevalent in online learning. It is implemented globally not only in the DoD and other U. S. Governmental agencies (ADLNet, 2006), but across Europe, Asia, Africa, and Latin America by governmental departments and institutions concerned with e-learning. Besides being implemented by most e-learning content providers and major corporations and institutions worldwide, SCORM is also extremely well-documented and is referenced in thousands of articles in scholarly and peer-reviewed journals, books and conference proceedings (Google, 2006). Currently, SCORM is in the process of a transition to a global organization for stewardship called Learning Education Training Standards Interoperability (LETSI).

In discussing simulations in the context of integrating within a LOCM, SCORM could then be considered representative of the standards-based LOCMs currently in use. As such, assessing SCORM for its ability to implement simulation-based learning experiences in an interoperable thin-client approach may allow some generalization to the greater universe of the current state of the standards-based LOCMs.

There are many advantages to having specifications and standards in learning technology. Typically these advantages center on the idea of interoperability or the ability for learning content to be used across different organizations or enterprises employing one or multiple LMSs. This concept can significantly reduce costs of development and redevelopment of learning content. A related but still mostly unrealized advantage to interoperability is that of reuse. Reuse can be and is defined in multiple ways but in the context of online learning it encompasses the idea of learning content being accessed in original or altered states by many different learners and/or authors/designers for multiple purposes many times. In other words, it is about reusing developed content over and over in the same or different context. The latter can also be referred to as repurposing (Doerksen, 2002). Reuse of online learning content, however, is mostly unrealized to date due to the lack of policy and infrastructure that currently exists across organizations as well as cultural barriers. Initiatives such as ADL's CORDRA (Content Object Repository Discovery and Registration/Resolution Architecture) when implemented are anticipated to have a positive impact on reusability. As with interoperability, the concept of reuse is part of the efficiency and economies-of-scale arguments for realizing e-learning as a means to lower training costs (Rehak, 2006; Wiley, 2006).

Connecting Simulations and Standards

Currently, simulations standards exist mostly in the form of the High Level Architecture (HLA) developed by the Defense Modeling and Simulation Organization (Defense Modeling and Simulation Office [DMSO], 2006) and approved as an open standard by the IEEE in 2000. The HLA is intended to facilitate interoperability and reusability among distributed simulations and their components within the DoD and is integral to the modeling and simulation community. However, these simulations currently facilitate collective training and exercises usually on large scales and do not have any discrete provisions for the tracking or supporting of individual training and education activities thus keeping the two worlds separate.

Most online simulations designed for individual use exploit standards and specifications supporting web browsing as developed through the World Wide Consortium (W3C). Typically browsers access web pages as a client with the web pages being served to the client (web browser) by a server. When using a standard web browser for web page access the web browser is referred to as a thin client. Non-browser applications residing on the client side but still exploiting web standards are referred to as thick clients.

Access occurs either through a thick client with proprietary functionality and communication protocols (Miller & Childs, 2004) or through other client-server based architectures. In these architectures the actual simulation engine is on the server side with the client used only for communication with the simulation through a user interface in a thin client (i.e. - web browser). There is movement toward the use of purely thin client-based simulations employing mobile code specification, standards, and technologies (Swinski & Williams, 2004).

In progress, multiple entities are collaborating on ways to develop interoperability standards between simulations, simulation engines, and LOCMs such as SCORM for individual training and tracking using a LMS. For example, the Simulations Interoperability Standards Organization (SISO) is currently working with industry, AICC, and ADL to develop specifications for simulation interoperability standards for SCORM to be added to the existing IEEE Learning Technology Standards. This would allow external simulation environments to track, assess, and provide data on an individual that could subsequently be stored and managed through an individual training event on a LMS. At this time, however, these specifications are still in the preliminary stage of standardization by bodies such as the IEEE.

SCORM 2004 Overview

The basic building block for online learning using SCORM 2004 is the shareable content object (SCO). A SCO is recognized as a learning object (Advanced Distributed Learning Partnership Lab UK, 2007; Kilby, 2004) and usually exhibits an innate instructional design (Pasini & Rehak, 2003). A SCO is mandated to communicate with a LMS and is the only environment in which it can be successfully launched. SCOs could also be considered a special type of web page(s) launched by and communicating with a LMS using specific data calls through an IEEE EcmaScript (also known as JavaScript) based application programming interface (API). Communication of such things as learner identity, book marking, SCO completion and mastery level occurs both from the LMS to the SCO and from the SCO to the LMS.

In the latest version of SCORM (SCORM 2004), an additional IMS specification called Simple Sequencing has been added as part of the Sequencing and Navigation Book of the SCORM documentation suite. The use of simple sequencing directs a LMS to automate the selection, sequencing, and progression of a learner through a defined collection of SCOs. The sequencing information for each course is contained within XML (extended markup language) data as part of the course manifest and reusable sequencing data are defined with usage suggestions as part of the SCORM Best Practices Guide for Content Developers (Learning Systems Architecture Lab [LSAL], 2004). As such it is beginning to be understood that sequencing data snippets can be defined and reused as specific patterns. These patterns could be representative of interactions and branching decisions that together with specific types of SCOs may instantiate or facilitate specific pedagogical models.

There are, however some issues with the SCORM architecture that may be confining it to an implicit declarative knowledge-based pedagogical model precluding its ability to facilitate more advanced models such as a simulation. Currently, there is no provision for a SCO to communicate directly with another SCO. Also, the use of indirect methods (LMS) for this communication is limited to the organization and structure of the CMI (computer managed instruction) data model - AICC's contribution to SCORM and part of the runtime environment. There is currently no prescribed method for a SCO to store arbitrarily complex state information in the runtime service that can later be retrieved by itself or by another SCO. This is a crucial requirement for state communication with interactive content such as simulations (IMS Global Learning Consortium [IMS GLC], 2006) and its lack thereof would present problems when data persistence from one SCO to another one is required (A. Panar, personal communication, May 11, 2007).

Problem Statement

Effective e-learning uses a variety of and a partnership of tools. These tools should be used to represent meaningful problems, situations and contexts (Norton, 2003). As learning and activity are considered inseparable and are embodied in tool usage, learning objects and resources should support the complex interactions required for meaningful learning. "Meaningful learning results from the recognition of a problem, the intention to solve it, the conceptual understanding of the system in which the problem occurs, the generation and evaluation of alternative solutions based on alternative perspectives, and reflection on the activities that resulted in its solution (Jonassen & Churchill, 2004)". The rich environment presented by a well-designed simulation allows for immersive learning, social negotiation, tool usage, and problem solving and is a useful method for creating effective engaging e- learning.

Training consists of learning and assessment activities for the acquisition of specific knowledge and skills and is based on many methods or pedagogical techniques. Individual training has traditionally been based upon a one-way transmission model of instructor (computer for online environments) to learner with the underlying assumption that the learner will gain knowledge and skills through this limited type of activity. However, learning to apply skills and knowledge requires much greater interaction; therefore "learning by doing" results in much more meaningful and effective learning

(Swinski & Williams, 2004). Unfortunately, effective, immersive, and authentic training and learning environment development is expensive and sometimes logistically impossible. Simulation technology provides a possible framework within which such immersive training might be conducted.

Simulations can also provide an authentic and effective assessment environment. By actually performing within a simulated activity, learners can be assessed on how well they can apply and understand what they have learned. Formatively, simulations can be used to help learners reflect on and shape their knowledge and skills. Summatively, simulations can be used as spaces to exhibit performances of understanding. For problem- based competencies, simulations make an excellent assessment tool to certify whether someone can problem-solve or perform analysis activities. An example of a summative reflective assessment is that of an after-action review of an exercise to highlight what was done right as well as identify areas of improvement (Aldrich, 2006).

SCORM is an established framework with ubiquitous conformant content that, along with its related LOCMs, does not easily allow learning to occur beyond the simple acquisition of declarative knowledge and is thought to fall very short in terms of cognitive and psychomotor skill acquisition (Jonassen & Churchill, 2004). To begin to utilize other pedagogical models such as simulations within this framework, these models need to be analyzed to determine whether they can be integrated into the existing SCORM or whether the existing SCORM needs to be extended to enable this type of training. This study analyzes an online simulation to establish a set of requirements to assess SCORM for its abilities in implementing those requirements while maintaining such innate SCORM tenets as interoperability and reuse.

Therefore, the problem of this study is to assess SCORM for its affordances facilitating the implementation of specific requirements representing a simulation-based model optimized for interoperability and reusability. This special set of requirements is called the Simulation Requirements Framework or SIMREF and will represent an assessment criterion. The study will address the overarching research question: Assuming the condition of the Run-time Environment (RTE) and Sequencing capabilities of the technical architecture of SCORM 2004 and a criterion of the SIMREF, are there gaps in the capabilities SCORM 2004 provides to facilitate a simulation-based pedagogical model optimized for interoperability and reusability? To answer this question, SCORM, specifically related to components of its technical architecture, will be assessed for its strengths and weaknesses in meeting the requirements of the SIMREF. Specifically, this study seeks to answer the following questions:

1. Are functional or typed SCOs necessary to fulfill specific requirements of the SIMREF? If so, which ones?
2. Using a thin client (non-server based) object based delivery mechanism, is it possible to fulfill the requirements of the SIMREF using SCORM 2004 without any extensions?
3. If extensions other than SCO to SCO data sharing are needed for SCORM 2004 to fulfill the requirements of the SIMREF what would they be?
4. Using a standard browser-based delivery mechanism, is SCORM 2004 sequencing adequate for fulfilling all of the requirements of the SIMREF? If not, what sequencing specific extensions are required?

5. Using a standard browser-based delivery mechanism, is complex arbitrary data sharing between SCO's necessary to fulfill specific requirements of the SIMREF?
6. Is it necessary to use customized LMS functionality and communications to fulfill specific requirements of the SIMREF?
7. As gaps are identified in fulfilling the requirements of the SIMREF, do relationships exist between them?

Significance of the Study

As the ubiquity of online learning continues to grow, so does its significance within the education and training communities. With online learning taking on more and more roles in corporations, higher education, and the military, the importance of standardizing online learning content development has emerged. Without such standardization, instructional designers will not be able to reuse, repurpose, and establish interoperability across LMSs. As with any standardized product, standardization inherently reduces customization or contextualization and in the online learning world, decontextualization is one aspect that drives questions of limitations in the ability to produce meaningful learning.

Other aspects of standardization that exposes these limitations are in the explicit descriptions of learning content required. Even though they claim to be pedagogically neutral, these descriptions instantiated in LOCMs are based upon specific assumptions of learning, reusability, repurposability, and interoperability instantiated in the LO metadata, aggregation, and API rendering neutrality virtually unattainable (Blandin, 2003; Kraan & Wilson, 2002). If these assumptions are faulty or incomplete in an LOCM, the quality of learning available to those learners supported by that particular LOCM will suffer. For example, if CISCO's LOCM called the RLO/RIO Model, does not support anything higher than declarative knowledge acquisition, those needing to develop a deeper understanding about a subject will be at a loss. These models may be adequate for basic knowledge acquisition within a corporation but as online learning is rapidly moving to support learning for understanding and higher order thinking skills, they will fail. This issue greatly reduces the ability or desire to pick and choose learning objects from multiple sources and communities and present them in the context of a course or to even use LOs at all (Rehak & Mason, 2003).

According to Duval, sophisticated reuse of LOs requires access to their components with the addition of dynamic repurposing - the ability to reuse and combine them in different ways on the fly. This level of reuse requires a very flexible underlying model of learning object components (Verbert & Duval, 2004) or LOCM. To evaluate learning objects in the context of meaningful learning or reusability, it is necessary to understand their object classes, components, structures, metadata and business rules or interaction models. These items can be thought of as their characteristics and comprise the components of an associated LOCM. Each LOCM is different in the way it describes each of these components and what is defined as an LO. For example, the definition of a learning object by SCORM differs from that of CISCO and it is not clear whether a SCORM learning object or component can be repurposed within a CISCO context (Verbert & Duval).

As a beginning in understanding and improving LOCMs, a primary research issue concerns the comparative analysis of these models and is subsumed under the overall

LOM Research Agenda (Duval & Hodgins, 2003). This agenda is further divided into the following categories defining research areas: learning objects (LO) and learning object metadata LO (M), authoring, access, and interoperability. This study is significant in its furthering of the LOM Research Agenda in understanding LOCMs and how they support learning.

Specifically, as SCORM is arguably the most prevalent LOCM in the field of online learning and with its structure, API, and run-time data model based upon prominent global specifications and standards as well as its close similarity to other current LOCMs, the assessment of SCORM is a micro assessment of not only similar LOCMs but of the standards and specifications it is composed of. In designing and executing a valid assessment of SCORM in respect to simulations, the field of instructional technology will have a potential tool to assist in the first steps of redesigning and improving LOCMs in their handling of other robust pedagogical models and contributing to the improvement of online learning as a whole.

Scope of the Study

The scope of this study is represented as a gap analysis using a survey-based design situated within the developmental research paradigm (Richey, Klein, & Nelson, 2004). It is concerned with understanding SCORM, as representative of current LOCMs, for its abilities to implement a simulation as a type of pedagogical model. The scope of this study is specifically focused on SCORM 2004 and the requirements derived from a specific simulation. An implementation of a simulation (one of many advanced pedagogical models facilitating meaningful online learning) may be somewhat representative of the implementation of other advanced pedagogical models. This analysis will give insight into SCORM in terms of strengths and weaknesses in respect to its ability to facilitate simulations. In so doing, a set of requirements representing a specific online simulation has been developed as the SIMREF. In the gap analysis methodology, the SIMREF represents the criterion and SCORM 2004 represents the condition.

The approach used in developing the SIMREF was a use-case approach commonly found in software development. In following this approach, an available instructional online simulation was chosen and a use-case level diagram was developed (Cockburn, 2001) based upon the inherent functionality of the simulation as it is commonly deployed as part of a learning environment. After formative evaluation activities, the requirements were scoped down to those specifically affected by a SCORM implementation. Although collaboration would be desirable to include as a requirement, it was decided to focus on individual users (learners) due to the inherent known issue of SCORM's inability to support collaboration at this time.

Definition of Terms

Pedagogical Model: a reusable structure consisting of a specific collection of instructional methods grounded in applied learning theory designed to produce defined learning outcomes. Specifically this structure is a reusable model or design of learning having the properties of an object in the paradigm of object oriented programming (OOP) embodying specific instructional theories and related strategies independent of specific learning resources. Although independent of specific learning resources, as a model it will incorporate other reusable resources such as learning objects depending on the specific learning outcomes required. An instantiated pedagogical model consists of curriculum content as learning resources or learning objects and methodology (or methodologies) as methods or services selected for their ability to bring about specific learning outcomes. Specific models incorporate pedagogical procedures or strategies which determine how learners will experience, engage with, and respond to the content.

Application program interface (API): An application programming interface (API) is the interface that a computer system or application provides in order to allow requests for service to be made of it by other computer programs, and/or to allow data to be exchanged between them. (Ostyn, 2007; Wikipedia-contributors, 2005). An API is used as a standardized method for learning objects to communicate with the learning management system (LMS) such things as student name or scores (LSAL, 2004). For example, SCORM's run-time environment functions as its API (Advanced-Distributed-Learning, 2004).

Granularity: The size of a learning object and optimization of this size is a necessary condition for their use and reuse (Duncan, 2003b). In learning object content models, granularity refers to the sizes of learning objects, their component parts, and how they all aggregate.

Interoperability: The ability of a system or a product to work with other systems or products without special effort on the part of the customer (Miller, 2000). Interoperability can be thought of as enabling information that originates in one context to be used in another in ways that are as highly automated as possible and is an attribute of the standardization and reuse properties of learning objects required to function across a wide variety of software systems and environments. Currently, interoperability refers mainly to the interactions between learning objects and learning management systems but is moving towards interactions between learning objects as well. More specifically, in this context, interoperability can be defined as the ability for objects from multiple and unknown or unplanned sources, to work or operate technically when put together with other objects or systems (Duval & Hodgins, 2003).

Learning management system (LMS): a software package that enables the management and delivery of learning content and resources to students. Most LMS systems are web-based to facilitate "anytime, anywhere" access to learning content and administration. Most reusable learning objects require an LMS to operate. Core functionality of an LMS usually allows for student registration, the delivery and tracking of e-learning courses and content, and testing, and may also allow for the management of instructor-led training classes. In the most comprehensive of LMSs, one may find tools such as competency management, skills-gap analysis, succession planning, certifications, virtual live classes, and resource allocation (venues, rooms, textbooks, instructors, etc.). Most systems allow for learner self-service, facilitating self-enrolment, and access to courses (Szabo & Flesher, 2002; W. R. Watson & Watson, 2007; Wikipedia-contributors, 2006).

Learning object content model (LOCM): models of learning object components and relationships addressing granularity and abstraction. The different types of learning objects and their components comprise their technical architecture made of object classes, components, aggregation, metadata, and business rules or interaction model or interoperability characteristics. The technical architecture of an LOCM embodies specific pedagogical characteristics or assumptions of learning found specifically in the definitions of object types, metadata applications, and interoperability characteristics (Verbert & Duval, 2004).

Learning objects (LO): is a collection of web pages that may or may not include embedded objects (Flash, Java applets, etc.) that have a learning purpose. For the purposes of this study, it will be assumed that a learning object will also need to exhibit specific properties such as those of defined granularity, reusability, standardization, and interoperability. As such, they are objects that are generally accessed and consumed through the use of an LMS (Wiley, 2002).

Metadata: literally "data about data," is descriptive information about a resource that enables us to assemble learning objects automatically (Wiley, 2002). As descriptions of data (in this case LOS), it allows LOs to be located and retrieved in order to be use and reused (Baruque & Melo, 2004). Examples of metadata are the information in a card catalog about a book or even a map providing metadata about geography (Hodgins, 2000; Wiley, 2001). Metadata usually exists as a collection of categories for description called a metadata model. One such metadata model is the Library of Congress card catalog system. For learning objects, the metadata model is defined by global standards organizations such as the IEEE as existing in the learning object metadata model or LOM (IEEE LTSC, 2005).

Reuseability: the ability of a learning object to achieve multiple outcomes across multiple contexts. This can occur in the number of places where an object can be accessed (deployability); the number of places where instances of the object has been used as a component part of another, more complex, object such as a course (component reuse); or the number of times a single learning has been accessed by an individual for learning purposes not related to other more complex objects (individual reuse) (Culwin, 2004). According to Sutcliffe, reusability has three main attributes: abstraction, coupling, and granularity (Sutcliffe, 2002).

Shareable Content Object Reference Model (SCORM): Web-based learning "Content Aggregation Model" and "Run-time Environment" for learning objects. At its simplest, it is a model that references a set of interrelated technical specifications and guidelines designed to meet the DoD's high-level requirements for e-learning content (Advanced Distributed Learning [ADL], 2004a). In the literature, SCORM is recognized as a learning object content model or LOCM (Katz, Worsham, Coleman, Murawski, & Robbins, 2004; Verbert, Dragan, Jovanovi, & Duval, 2005; Verbert & Duval, 2004; Verbert, Klerkx, Meire, Najjar, & Duval, 2004).

2. Literature

Introduction

The purpose of this chapter is to provide insight and clarity into the domain of learning object content models (LOCM), e-learning standards, simulations as a pedagogical model, SCORM 2004 as the condition of the gap analysis, and the description of the criterion and how it was derived. To outline the conceptual framework of the study and to present a common lexicon, a discussion is first presented to clarify what is meant by learning objects, reusability, interoperability, LOCM, and learning management systems and their variations.

This chapter then describes the condition and the criterion. For the condition, it was necessary to clarify and define the components of SCORM 2004 for understanding and to guide the assessment design. For the criterion, it was necessary to clarify what is meant by pedagogical models and how these models can be applied online. This is followed by a discussion of simulations as a type of pedagogical model, their characteristics, and how they are applied in online learning. A following discussion ensues concerning PharmaSim as a concrete example of an online simulation as a learning environment. Finally, a discussion of requirements derived from PharmaSim using Unified Modeling Language (UML) is presented to allow clarity into the SIMREF creation process.

Learning Objects

> It may surprise you that no single learning object definition exists within the e-learning industry. Learning objects are different things to different e-learning professionals. In fact, there seems to be as many definitions as there are people to ask (ASTD in Sosteric & Hesemeier, 2002, p. 2).

Definition

Learning objects (LOs) as they are conceived have their roots in computer science and are elements of computer-based instruction derived from the object-oriented paradigm in computer science (Downes, 2001; Wiley, 2001). Online courses and learning objects are just another application from the perspective of software engineering. Software engineers have long advocated that is it inefficient to design applications from scratch (Downes, 2001) and have embraced object-oriented design for that reason. The object-oriented paradigm is seen as facilitating a "design for reuse" strategy (Sutcliffe, 2002) and, therefore, has reusability as one of its primary attributes.

There are many definitions of learning objects and, depending on the definition selected, could include virtually anything that could conceivably fit into an instructional or educational context. Definitions range from items as small as a paragraph of text or as large as a whole training course or physical objects in a museum and their virtual representations (Barritt & Alderman, 2004; Sierra, Fernandez-Valmayor, Guinea, Hernanz, & Navarro, 2005). The IEEE states that a learning object is defined as any entity, digital or non-digital, that may be used for learning, education, or training (IEEE LTSC, 2002). It is generally accepted, however, that a learning object is a reusable collection of web pages that may or may not include embedded objects (e.g. Flash or Java applets) and that has a learning purpose or, in other words, any digital resource that can be reused to support learning (Wiley, 2002). A variation of this definition includes instructional scaffolding as a necessary attribute (Metros & Bennett, 2002).

The IEEE distinguishes between learning objects and content objects, stating that content objects are a collection of digital content that is intended for presentation to a learner by a learning technology system (i.e. LMS). Content objects may include learning material and processing code. For example, a content object might be a HTML page with an embedded video clip and an ECMAScript (IEEE, 2004). Other object names and types that typically appear when discussing LOs are media objects, interactive learning objects, and information objects. Information objects are sometime used synonymously with content objects but not usually with learning objects (Rehak & Mason, 2003). Object nomenclature and typology are typically defined by a LOCM.

In other definitions, learning objects are considered the smallest independent instructional experience that contains an objective, a learning activity, and an assessment (L'Allier, 1997). Learning objects are also considered as discrete chunks of reusable learning materials or activities that can communicate with other learning objects to build a learning environment (Koppi, Bogle, & Lavitt, 2004). Koper (2003) narrows the definition to "…any digital, reproducible and addressable resource used to perform learning activities or learning support activities, made available for others to use" (p. 47). The variety of multiple definitions creates a general lack of clarity and a conceptual confusion. The definitional problems with LOs are perceived to undermine the ability to understand and critically evaluate LOs as an emerging field (Sosteric & Hesemeier, 2002).

Learning objects are concerned with specific properties such as those of granularity, reusability, standardization, communications, and interoperability and are generally accessed and consumed through the use of a LMS. Of these specific properties or characteristics, the most common one is reusability. However, Polsani (2003) posits two fundamental predicates for the concept of a learning object: learning intention and reusability. Within the predicate of the learning intention lies form and relation. Form is essentially the setting, context, and environment in which the learning object is embedded. Relation refers to the properties within the learning object by which it relates to the learner facilitating understanding. Value is then added to the internal constitution of a learning object through its ability to be reused.

All definitions except that of the IEEE include reuse or reusability as an innate and fundamental trait of learning objects (Koper, 2003; Koppi et al., 2004; Polsani, 2003; Wiley, 2002). The term "reusable learning object or RLO" is widely accepted and has been coined through the early work by Cisco and by Barrit and Alderman (Barritt, 2001; Barritt & Alderman, 2004). Reuse is also referred to in the literature as sharing (Treviranus & Brewer, 2003). ADL uses the term "shareable" for the nomenclature of its learning object definition called the shareable content object (SCO) (ADL, 2004a).

The previous characteristics of learning objects as well as others such as granularity or scope ("standing on its own") and decontextualization (Koper, 2003; Koppi et al., 2004) all contribute to the reuse of learning objects, placing the primary characteristic as reusability. As another aspect of value, reuse is seen as a necessary condition to gaining economic benefits from educational technology (Duncan, 2003b).

Even though much emphasis is placed on reusability, one other attribute that stands out is that of communication. Communication is essential (Koppi et al., 2004) and results from a design aspect called coupling - the degree to which each component or object relies on each one or more other components or objects (Sutcliffe, 2002; Wikipedia, 2007). Communication between learning objects and their environment (i.e. LMS) facilitates real-time reuse, learner tracking, and learning customization. Individual learner tracking and learning customization may not be reflective of the current thinking in pedagogy because of its self-directed single learner model (McCormick, 2003) but this model is used ubiquitously in corporate and military training reflecting the "anytime anywhere" self-directedness of andragogy (Hiemstra, 2006; Knowles, 1984). Therefore, tracking and learning customization reinforce the need for good communication models between learning objects and their respective learning and/or delivery environments.

Reusability

Reusability is the ability of a learning object to achieve multiple outcomes across multiple contexts (Culwin, 2004) with attributes of deployability, component reuse, and individual reuse. The concept as also incorporates the availability of or sharing of learning objects for others to use, meaning that when a learning object is used in one learning context it is also available for reuse in another (Koper, 2003; Treviranus & Brewer, 2003). Reuse can occur in the number of places where an object can be accessed (deployability); the number of places where instances of the object has been used as a component part of another, more complex, object such as a course (component reuse); or the number of times a single learning object has been accessed by an individual for learning purposes not related to other more complex objects (individual reuse) (Culwin, 2004).

The property of reusability in LOs is not limited to the object itself but also to the type of pedagogy it employs or the pedagogical model it is apart of. The concept of pedagogical reuse is discussed with reusability attributes by (Pitkanen & Silander, 2004).

Reuse can only occur and survive when there are libraries or repositories of reusable components (i.e. LOs). This would mean that these components are the result of a specific strategy, designed for reuse with a required infrastructure to support them. Thus, it is necessary to include in the concept of reusability's three main attributes: abstraction, granularity, and coupling or encapsulation (Koper, 2003; Sutcliffe, 2002). In terms of a learning object, these attributes also include interoperability and accessibility (Duncan, 2003b; Koper, 2003). Koppi also describes an important attribute for reusability as recontextualization – the ability of learning objects to be used in different contexts and combined in different ways (Koppi et al., 2004). This concept is also referred to as repurposing (Treviranus & Brewer, 2003). However decontextualization as well as recontextualization (repurposing) can be considered a result of abstraction, granularity, and coupling and hence will be subsumed into the following discussion of these properties.

Abstraction

The concept of abstraction encompasses the selective removal of information deemed to be of diminished importance with respect to a particular perspective, concern, or focus. Therefore, abstraction reduces detail while retaining the essence of meaning.

The difficulty is in deciding what that meaning will be (Sutcliffe, 2002). However, abstraction occurs everyday as individuals reason, memorize, and learn. As memory is selective, individuals abstract essential information about problems or events and store them in an abstract model. In computer science, abstraction is usually achieved through the construction of generalized models or generalization. Higher levels of abstraction tend to have a lower granularity in the development of reusable design, code, or objects. However, abstraction and granularity do not necessarily have a negative correlation and are not thought of as being completely orthogonal. Objects or designs that are highly abstract may not be small in scope, and each reflects separate design decisions (Sutcliffe, 2002).

For the design of learning objects, abstraction usually means the separation of learning content from context or decontextualization. This can be difficult as content organization and presentation are generally centered on an instructional objective or goal. Abstraction can also mean the absence of a specific instructional design with the intention of being pedagogically neutral. A part of the ongoing debate about LO abstraction concerns whether or not instructional design can be removed from a learning object while still retaining its instructional nature and value (McCormick, 2003). Polsani (2003) advocates abstraction as the way to provide LO independence from use and strong performative ability, facilitating combinations with other LOs for instructional intentions. This recombination is related to the concept of recontextualization (Koppi et al., 2004) and, consequentially, puts the onus of providing the context either on the ICT system (virtual learning environment or LMS) or on an instructor (McCormick, 2003). However, part of the overall conflict occurs because contemporary epistemologies emphasize the situated nature of learning, and this issue becomes more acute when LOs are seen as more than content objects whose dominant pedagogy is the transmission of information (McCormick, 2003).

As a design consideration in determining the reuse strategy of learning objects, the approach to abstraction must be considered and applied consistently. One model of defining abstraction is to tightly couple LO with specific instructional models allowing the most abstraction (and, consequently, reuse) to fall on the actual components of the LO relying on the use of content management and asset management systems (Gallagher, 2005). Although extremely important in the application of LOCM and as with granularity, abstraction is not defined or standardized and, therefore, thought to allow maximum flexibility in the design and implementation of LOs.

Granularity

The size of a learning object and optimization of this size is a necessary condition for its use and reuse (Duncan, 2003b). In LOCMs, granularity refers to the size of learning objects, their component parts, and how they aggregate. Though not completely at odds with abstraction, granularity does tend to have a negative correlation with reusability. The larger an object is, the lower its possibility of reuse.

The concept of breaking learning resources into granular objects and rebuilding them into other or different learning resources is generally conveyed through the use of metaphors. The two common metaphors used are that of Lego blocks and the atom (Duncan, 2003b; Wiley, 2001). While one metaphor points to discreet blocks that combine easily into a larger whole, this metaphor suggests the need to only use blocks that fit with final results always having a distinctive “blocky” shape. Alternatively, the atom metaphor is designed to show components, recombination, and aggregation. Furthermore, the atom metaphor analogizes specific types of combinations that have high pedagogical value and those that do not, explicating the difficulty in creating learning objects that combine easily and allow for instructional integrity across multiple situations.

Granularity can be thought of in levels of aggregation that define the scope of the LO. These levels are defined in specific LOCMs and usually consist of approaches based on educational unit, purpose, and size. These terms are not standardized, may or may not be forced by the LOCM, and include the following: (educational) course, module, unit, and topic; (purpose) asset, reusable learning object, content object, and activity; and (size) number of pages and duration to complete. In practice, granularity may be defined by combinations of educational and purpose terms, educational context (Duncan, 2003a), or instructional purpose. However, when discussing the granularity of a LO, all other purpose terms are excluded. This makes the granularity definition wholly dependent on the educational unit of aggregation it is intended to support as well as the educational context and its instructional purpose. It is here that pedagogy also comes into play. For example, if a LO is designed to support a learning goal in a constructivist model, its design, and hence its granularity, may be very different from one designed to support or teach an enabling objective.

Coupling

To combine, recombine, or recontextualize LOs, there must be interaction between LOs and a LMS or a VLE through a run-time service which also mediates interactions between LOs. How these LOs interact with and are dependent on the run-time service or each other is defined by a concept called coupling. Coupling, defined as either tight or loose coupling, is the third attribute facilitating reuse. How coupling occurs is also a prominent factor in the design of a service oriented architecture (SOA) the current paradigm for component or service reuse. Running as a subtext to any discussion of LOs, a general understanding of a SOA helps to situate an understanding of coupling.

Service orientation, as a means of separating things into independent and logical units, is a common concept in software engineering (Thomas, 2005) and is the basis for reusing software functionality. A SOA is a software structure or "…architecture for building applications that implement business processes or services by using a set of well-defined loosely coupled black-box components designed to deliver a well-defined level of service" (Hurwitz, Bloor, Baroudi, & Kaufman, 2007, p. 27).

In a SOA, the software architecture defines which software components to use and how those components interact with each other (Hurwitz et al., 2007). In LO design, this architecture is embodied in a course or other instructional unit as defined by an instructional designer. This parallel is significant as the design and implementation of LO face the same issues as that of designing and implementing services in a SOA. In fact, the distinction between the two is blurring. For example, the communication channels and functionality within the SCORM-based Integrated Prototype Architecture (IPA) is being prototyped using web-services, a staple of SOA implementation (Travers, 2007). Also, services and service layers are being employed in the development and implementation of cooperative learning objects (Young-Sik & Seong-Hun, 2005), and content objects are being described as web-services with Web Service Description Language facilitated by employment of OASIS' Universal Discovery, Description, and Integration (UDDI) specification (Christensen, Curbera, Meredith, & Weerawarana, 2001; Organization for the Advancement of Structured Information Standards UDDI Specification Technical Committee [OASIS USPTC], 2007; Su & Lee, 2003).

Tight coupling is also called high coupling and means that objects communicating with each other do so with data structures and methods specific to the functionality of each object. This occurs because of strong assumptions made about the type, format, and quantity of data being communicated and is a result of the object or component having some model of the external world embedded within it (Sutcliffe, 2002). This type of coupling has low reuse because interaction with other objects is severely limited to just those objects it can communicate with. Components, objects, or systems that tend to be tightly coupled are often referred to as white-box systems (Sutcliffe, 2002) because their transparency and dependency on other systems results in communication with specific internal functionality between systems (Hurwitz et al., 2007).

The desire in reusable component or object design is to create loose coupling or black-box systems. These systems are dependency free or independent of the functionality of other systems or components. Black-box components do not expose specific functionality to other components or objects but communicate with them through common data structures usually referred to as their application programming interface (API). With dependency-free components or services (i.e. LOs in this context), these components or services can then be linked together to create a composite (learning) application (Hurwitz et al., 2007). Using this method, disparate LOs can be joined together to fulfill multiple learning purposes. In this manner, component services come together and come apart easily and are loosely coupled. In other words, the component services are not intertwined in the way traditional applications are, are not dependent on each other, and can be mixed and matched with other component services as needed (Hurwitz et al., 2007; Sutcliffe, 2002). An important aspect of loose coupling is that the component services or objects and the API are deliberately separated so that the service or object itself has no code related to managing the computing environment. Because of this separation, components can function together dynamically in real time as if they were a single, tightly coupled application (Hurwitz et al., 2007; Thomas, 2005).

A specific example of loose coupling within the LO context is the separation of content from presentation. This occurs through the use of different presentation templates and a content management system (CMS) allowing learning content to be exported from the CMS in different formats with different user interfaces (UI). This type of functionality is considered to be an important tenet in the use and reuse of LO especially in the quest for dynamic personalized learning applications (Treviranus & Brewer, 2003).

Interoperability

Interoperability is considered the ability of a system or components to work with other systems or components without special effort on the part of the end user (Miller, 2000). As coupling is a design decision, interoperability could be considered the product of coupling design. Loosely coupled components are much more interoperable then tightly coupled ones.

Interoperability can be thought of as enabling information that originates in one context to be used in another in ways that are as highly automated as possible. Using the Lego analogy, Lego blocks can be used to build a variety of structures because of their standardized interface. Therefore, they are considered to be interoperable, at least in the Lego environment. Interoperability of LOs is an attribute of the standardization of their communication structures and protocols required to function across a wide variety of software systems and environments (i.e. multiple LMS and their variations).

Currently, interoperability refers mainly to the interactions between learning objects and learning management systems but may extend toward interaction between LOs as well. More specifically, in this context, interoperability can be defined as the ability of objects from multiple and unknown or unplanned sources to work or operate technically when put together with other objects or systems (Duval & Hodgins, 2003).

Accessibility

Most definitions of LOs have accessibility as an attribute (Polsani, 2003; Treviranus & Brewer, 2003). However, the meaning of accessibility may not always be clear or consistent. In the literature, there are two primary definitions. One primary definition of accessibility is in the design for discovery and use by all types of learners as in the accessibility provisions of Section 508 of the Americans with Disabilities Act (Government, 1998; Treviranus & Brewer, 2003). This means that LOs need to be designed and implemented with affordances for those with different types of disabilities as well as to those without them. An example of designing for accessibility in this context is to design alternative text for images that is meaningful and descriptive. This design would facilitate someone who is visually impaired who might be using a screen reader to read the learning content.

More germane to the current discussion is a second definition of accessibility that states that accessibility is the ability to locate and access instructional components or learning content from one remote location and deliver them to many other locations wherever and whenever they are needed (ADL, 2006a; Hodgins, 2000; Katz et al., 2004).

Likewise, Educause states accessibility is a state where learning objects can be located and delivered to the learner efficiently (Metros & Bennett, 2002).

As with reusability, accessibility can only occur and survive with libraries or repositories of reusable components or objects (Sutcliffe, 2002). The accessibility of LOs requires one or more repositories that are accessible or available to learners with a corpus of LOs that can each be discovered and used as the learning situation demands. It is for this reason that LO metadata exists with common schemas such as those by the IEEE (Learning Object Metadata (LOM)) and the Dublin Core. It is also for this reason that in the SCORM 2004 3rd Edition the requirement to use the IMS metadata schema has been dropped (ADL, 2006a). Metadata schemas supporting accessibility tend to be domain or enterprise specific, and organizations may need to develop and implement their own metadata in concert or in place of the standard metadata schemas available. This need has also initiated registry efforts such as the ADL's Content Object Repository and Registration Architecture (CORDRA) reference model, a formal model that can be used to design federations of repositories (Jesukiewicz & Panar, 2006).

Functionality

Until recently, discussions concerning LOs have centered on the delivery of content with or without a pedagogical approach. However, as learning design theories and practices begin to rely on collections of LOs as activities and even collections of activities, the role of LOs has been changing or, at least, expanding to include specific software functionality or software objects as well as learning content delivery (Su & Lee, 2003). For example, if the pedagogy of an activity deployed and managed by a LMS is more exploratory or generative in nature and reusability is a major factor, some of the components of the activity may need to supply specific functionality such as management, governance, or data storage much like a service in a SOA. In an activity based upon a simulation (exploratory), a component may need to perform a coaching function or a status reporting function. Other components in the activity may function as an embedded simulation engine or an assessment service to the simulation. Other functionality may include the need for collaboration and collaboration services as LOs embed themselves more and more in the online education toolset of higher education (Ip & Canale, 2003). Within Department of Defense (DoD) training, there is a current shift blurring the line between LOs and services evidenced by current funding trends in the research and prototypical projects from DoD funded organizations such as the Joint ADL Co-lab (Joint Advanced Distributing Co-lab [JADL], 2007).

Learning Object Content Models

The employment and reuse of learning objects to facilitate meaningful learning experiences requires an innovative and flexible underlying model (Verbert & Duval, 2004). This underlying model has been embodied in what is called a learning object content model (LOCM). LOCMs provide a common representation of learning objects and their components (Verbert et al., 2004). Other models may refer to LOCM functionality as frameworks (Baker, 2006) in their title but consider them as a type of LOCM. Essentially, a LOCM is a model of learning object components and relationships addressing their structure and communication protocol. This translates into a system of governance concerning abstraction, granularity, and coupling.

LOCMs have a technical architecture describing object classes, components, aggregation, metadata, the business rules or interaction model, and interoperability characteristics. These models bring together in a technical architecture a model of content aggregation, a run-time model for LMS communication, and a metadata model to describe the content and the aggregations. In so doing, they define a taxonomy or ontology (Verbert et al., 2004) of objects, their behaviors, and their descriptions that aggregate to form executable LOs, learning activities, modules, units, or courses depending on the philosophy and design of the LOCM. The technical architecture design of a LOCM also embodies specific pedagogical characteristics or assumptions about learning (Koper, 2003; Kraan & Wilson, 2002). These assumptions are found specifically in the definition of object types or aggregation model, the type of data and logic of its run-time model, and the schema within its metadata applications (Blandin, 2003).

The technical architecture of a LOCM may be comprised of standards and specifications or may be proprietary wholly or in some part. In the continuum, those that are concerned with interoperability use open standards and specifications on one end and those concerned with being proprietary on the other end. Examples of open specifications or guidelines in use today are the IMS Content Packaging (IMS GLC, 2005) and Simple Sequencing (IMS GLC, 2003a) Specifications and the AICC CMI data model (Aviation Industry CBT Committee [AICC], 2004, 2005).

As LOs have developed as a part of the online learning lexicon, several LOCMs have been developed and implemented to some degree. These models are very similar in nature, describing similar content aggregations, but it is not clear whether they employ a variation of the AICC CMI or a proprietary run-time model for communication with a LMS. In a 2004 comparative analysis of LOCMs, the following models were described: the Learnativity content model, the Microsoft model , the ADL academic co-lab model, the SCORM content aggregation model, the CISCO RLO/RIO (reusable information object) model, and the NETg learning object model. For analysis, Verbert and Duval also devised a model (aggregation only) called the General Learning Object Content Model (Verbert & Duval, 2004).

Upon analysis, these models are similar because their historical roots lie in the convergence of Information Mapping (Horn, 1998), Component Display Theory (Merrill in (Reigeluth, 1983)), and LO design (Clark, 1998). Specifically, the CISCO RLO/RIO embodied all three while the NETg leaned toward Component Display Theory with additional work by its designer (L'Allier, 1997). Both models include a specific structure for a LO. CISCO combined objects called Reusable Information Objects (RIO) including an overview, a summary, and an assessment into a Reusable Learning Object (RLO) (Barritt, 2001). Each RLO can have from five to seven RIO. NETg's model also has a strong structure for its LO which it defines "…as the smallest independent instructional experience that contains and objective, a learning activity, and an assessment" (L'Allier, 1997, p. 5). The other models listed above were developed later and embodied characteristics from both RLO/RIO and NETg. This foundational work has so influenced the design of these and later models such as the IMS specifications and the SCORM that essentially they could all be considered variations of a theme. It has also been stated that rich semantic and behavioral models of learning content do not exist and more complex models are required (Rehak & Mason, 2003). The underlying pedagogy embodied in the architectures of most LOCMs is one utilizing a transmission model of information and individualized self-directed learning experiences (Blandin, 2003; Dodds & Fletcher, 2004; Jonassen & Churchill, 2004; Koper, 2003; Kraan & Wilson, 2002; Oliver & McLoughlin, 2003).

To address current trends in teaching and learning, other theories and models have been posited and prototypes of supporting tools have been and are being produced (Harper, Bennett, Lukasiak, & Lickyer, 2005). Merrill developed Instructional Transaction Theory (ITT) and an object model to support it (Bannan-Ritland, Dabbagh, & Murphy, 2001; Merrill, 2000). Other models include the Smart Learning Design Framework (SLDF) (labeled as an alternative learning object model) (Harper et al., 2005; Lukasiak et al., 2004) and the Chasqui model within the Chasqui Approach (Sierra et al., 2005) with prototypes being implemented for the SLDF.

Designed to include functional or software objects and services is an extension of Su and Lee's reusable learning content model. It defined content objects and their constraints with a constraint-based Web-service registry/broker for dynamic discovery and invocation of executable content and software objects. It also introduced a rule-based learning definition process model and a learning process execution engine for the definition and enactment of learning processes modeling instructional courses and modules (Su & Lee, 2003). Another model of interest is the Knowledge Puzzle Content Model using an ontological approach to content aggregation modeled in the Semantic Web paradigm (World Wide Web Consortium [W3C], 2007a; Zouaq, Nkambou, & Frasson, 2007).

There also exist other inclusive models that allow for collaborative and instructor facilitated approaches such as the Open University of the Netherlands' Educational Modeling Language and the IMS Learning Design specification (IMS Global Learning

Consortium, 2003b; Koper & Tattersall, 2005). These models are learning design centric, encompassing a broad scope of learning objects, services, activities, and roles crossing over between the online and the physical environments.

In the LOM Research Agenda, Duval and Hodgins describe a reference architecture stating concerns for a LO implementation. These concerns state that LOs should be based on a common component-based approach, use structured content based on a common hierarchical data model, employ metadata at each level of the content hierarchy, provide a process methodology, and provide a technical infrastructure for developing, assembling and managing reusable granular content objects (Duval & Hodgins, 2003). As a LOCM is the governing model for a specific implementation of LOs, these concerns can be construed to be the general concerns of a LOCM. A concern that is of paramount importance is that of developing, assembling and managing reusable granular content (learning) objects or, in other words, authoring and managing learning content. In discrete terms, a LOCM provides a content aggregation model, a multi-level metadata model corresponding to the aggregation model, an authoring process, and communication and management methods. So not only does LOCMs support the delivery or accessibility of learning content and activities but learning content authoring as well.

As LOCM identify different types of learning objects and their components, they also provide a more precise definition of what learning objects are and allow the identification and exploitation of learning object components and their repurposing (Verbert & Duval, 2004). They do this through defining a component or building block taxonomy that can be assembled as different aggregations of content typically through the use of XML definitions in accompanying manifests or virtual packing slips.

Manifests describing the content are based upon a content packaging definition such as the IMS Content Packaging Specification (IMS GLC, 2005). Most models use a similar taxonomy of components based upon aggregations of content from assets or information to LOs to activities or modules. These aggregations usually culminate in an overarching aggregation called a course. However, some models are more specific about their nomenclature than others. SCORM 2004 could be considered one of the most loosely defined in this regard (ADL, 2006d). The use of taxonomies defines these components as hierarchical in nature. However, this does not always need to be case. Other more lateral and semantic ways of defining aggregations are being researched using an ontology instead of combined with a taxonomy (Verbert et al., 2005; Verbert et al., 2004).

Learning Management Systems

A learning management system (LMS) is an enterprise level (i.e. organization-wide) networked software package that enables the management and delivery of learning content and resources to students. Most LMSs are Internet/Intranet-based to facilitate "anytime, anywhere" access to learning content and administration through a web browser. The Learning Systems Architecture Lab at Carnegie Mellon states that, “A Learning Management System (LMS) is a software package used to administer one or more courses to one or more learners. An (*sic*) LMS is typically a web-based system that allows learners to authenticate themselves, register for courses, complete courses and take assessments” (LSAL, 2004, p. 5). LMSs are based on a variety of development platforms (e.g. Java Enterprise Edition or J2EE based architectures and Microsoft .NET) and usually employ the use of a robust database back-end. Most systems are commercially developed with license fees and code restrictions. However, free and open-source models also exist (EduTools, 2007; Wikipedia-contributors, 2006).

LMSs are utilized within virtually all organizations requiring training or professional development and are the foundation for most corporate e-learning programs (Hall, 2002). They are a major component of most Federal Government training programs and are used extensively throughout the DoD. LMSs have also become a staple of the online education provided by learning institutions throughout the spectrum of education from K-12 through higher education. Within higher education and following the pattern of library and enterprise resource planning (ERP) systems, LMSs are fast becoming a campus utility, expected to be available 24x7 (Camp, DeBlois, & Committee, 2007). LMSs are now considered mission critical and have appeared as one of the chief information officers' (CIO) list of top 10 information technology issues in higher education. According to (Camp et al., 2007):

> …findings suggest that overall penetration in higher education has increased by a factor of three since 2000; more than 90 percent of campuses support at least one C/LMS, with nearly 70 percent standardized on a single commercial C/LMS; and although more faculty are using C/LMSs, they are selective and, more often than not, are focused on administrative tools and less on interactive features. (p. 28)

Beyond their simple, basic functionality, all LMSs cater to and focus on different educational, administrative, and deployment requirements. Watson and Watson (W. R. Watson & Watson, 2007) point out the systemic nature of a LMS and that it is the infrastructure for delivering and managing instructional content, assessing individual and organizational training goals, tracking progress towards meeting those goals, and reporting overall training data of an organization. LMSs, having their roots in computer managed instruction systems (CMI) as well as computer-based training (CBT) and integrated learning systems (ILS), are enterprise-wide in nature and are described as managing the complete instructional program(s) of an organization. Szabo and Flesher (2002) describe and differentiate LMS from computer managed instruction this way:

> Learning management systems are computer based database and presentation systems which manage the entire instructional program and learning progress of employees with respect to the competencies specified by the goals and objectives of an organization. Computer managed instruction systems, from which LMSs are derived, manage the learning program of individuals in terms of 1) diagnostic assessment of performance relative to some standards and 2) prescriptive assignment of learning resources relevant to those standards. (p. 1)

Besides CMI, the evolution of LMSs has its roots in computer-based training (CBT) and its counterparts (J. Watson & Ahmed, 2004) as well as integrated learning systems (ILS), a term originated by Jostens Learning to describe the management system component of the PLATO K-12 learning system (W. R. Watson & Watson, 2007). The evolution from CBT occurred through the introduction of the WWW that allowed relatively inexpensive microcomputer-based training materials accessible to one learner at a time evolve into web-based training materials accessible to vast numbers of learners simultaneously. This movement also began to define the environment of instructional design as authoring of training content needed to conform to and exploit the new capabilities of the WWW (J. Watson & Ahmed, 2004). The migration of CBT to the WWW opened new capabilities in the delivery and management of instructional content on a broader scale with much more flexibility.

Although described as an ILS by Jostens, the PLATO system could be considered the first learning management system. It operated on a Control Data Corporation (CDC) mainframe computer that, over time, progressed from dumb to smart terminals (Szabo, 2002; Szabo & Flesher, 2002). This environment provided functionality to the learners, rivaling learning experiences currently obtained through web technologies such as Java and ActiveX (Meer, 2003).The Plato architecture gradually faded as LMS vendors began using a network of smaller personal computers and servers based upon today's web-based technologies (i.e. transmission control protocol/Internet protocol or TCPIP).

Because of the evolution of ICT, lower costs and ease of implementation of large server-based databases, LMSs have emerged from the remnants of early mainframe-based CMI. With high perceived ROI (returns on investment), LMSs are implemented to help increase organizational efficiency. Even though they possess a rich heritage in learning theory, it has largely been lost or understated by commercial ventures. There are, however, several benefits that are attributed to LMSs such as:

- Reducing costs through decreased training redundancy and reduced operational errors and down-time,
- Maximizing efficiency through the integration of content delivery such as safety issues, operating procedures,

maintenance packages, environmental standards, and job reference reducing complexity and costs of auditing, and

- Leveraging existing resources by including established policies and procedures; utilizing existing training material and links to "off-the-shelf" commercial computer based courseware (Szabo & Flesher, 2002).

Functionality

Currently, core functionality of LMSs usually allows for student registration, the delivery and tracking of e-learning courses and content, and testing. Core functionality may also allow for the management of instructor-led training classes. In the most comprehensive of LMSs, one may find tools such as competency management, skills-gap analysis (Gilhooly, 2001), succession planning, certifications, virtual live classes, and resource allocation (venues, rooms, textbooks, and instructors). Most systems allow for learner self-service, facilitating self-enrolment and access to courses (Wikipedia-contributors, 2006). According to (Plateau Systems, 2007), their LMS can deliver training to anyone anywhere throughout the organization, define and assign competencies by job role and/or individual, maintain records of training delivered for compliance purposes, deliver tests and exams to assess knowledge and provide certifications, and distribute training scheduling and administration.

Bailey in (W. R. Watson & Watson, 2007) presents general characteristics of LMSs in education that include: tying instructional objectives to individual lessons, incorporating lessons into the standardized curriculum, extending courseware several grade levels consistently, providing a management system collecting the results of student performance, and providing lessons based on the individual student's learning progress. Further functionality is defined by the American Society of Training and Development (ASTD) as enabling integration with the human resources system; incorporating tools enabling the administrator to manage registrations, curricula, certifications, budgeting, and scheduling; provide access to content delivery, develop content including authoring, managing and storing; integrate content with third-party courseware, assess learners' competency gaps, support assessment authoring, adhere to standards, support configuration to function with existing systems and processes; and provide data security (W. R. Watson & Watson, 2007). ADL states that a LMS refers to a suite of functionalities designed to deliver, track, report on and manage learning content, learner progress and learner interactions (ADL, 2004a). LMSs are typically designed for multiple publishers and content providers and usually do not include their own authoring capabilities. Their main focus instead is on managing content created from a variety of sources (Hall, 2002).

Because LMS functionality seems to be all encompassing and is an overarching enterprise-wide system, clarifying exactly what is meant by the term "LMS" is still somewhat ambiguous. There are at least two other types of systems each with subordinate or complimentary functionality that are commonly referred to as LMSs: course management systems (CMS) and learning content management systems (LCMS).

According to ADL, the term "LMS" can apply to very simple course management systems or highly complex enterprise-wide distributed environments, furthering the ambiguity of what is meant by a LMS. A highly generalized model showing potential components or services of a LMS is shown in Figure 1. Typical services that are all targeted to track and manage learner progress may include back-end connections to other information systems, sophisticated tracking and reporting of student activity and performance, centralized registration, online collaboration, and adaptive content delivery (ADL, 2004a).

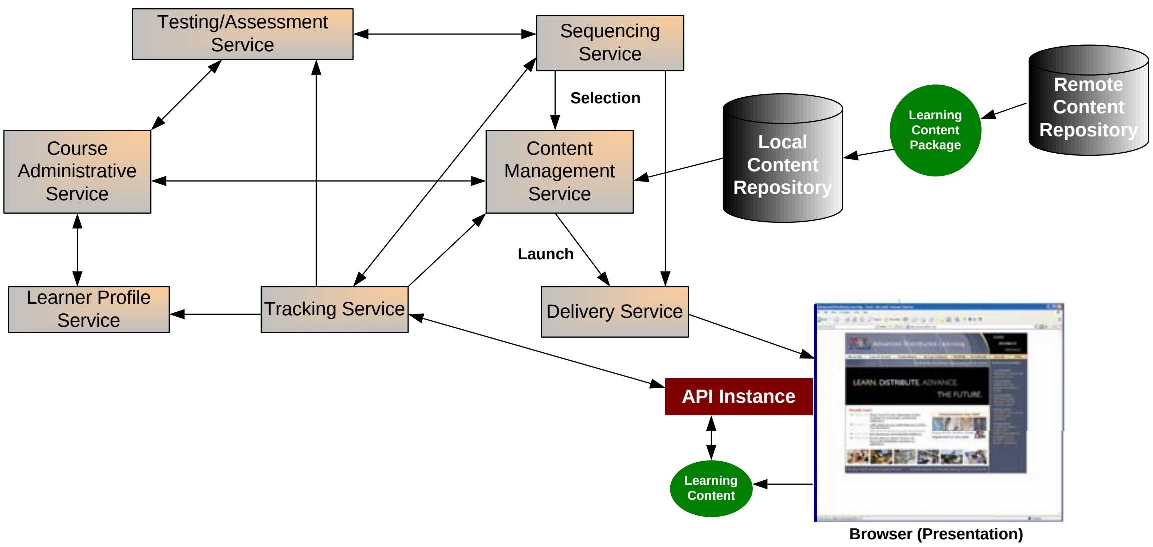


Figure 1. Functionality by Service (ADL, 2006)

Course management systems are so closely related to LMSs that the term is sometimes found combined as in C/LMS or used interchangeably (Camp et al., 2007). These systems include both commercial and open source systems exemplified by Blackboard, WebCT (recently merged with Blackboard), Moodle, Angel, .LRN, Sakai, and ClassWeb (EduTools, 2007; W. R. Watson & Watson, 2007). CMS are used primarily for online or blended learning, course materials placement, student to course placement, tracking student performance, storing student submissions, and mediating teacher/student or student/student communications (W. R. Watson & Watson, 2007).

There is significant overlap in some functionality with LMS. However, the systemic nature of LMSs and their broader functionality is not present in CMS.

LCMS are very closely related to LMS, providing much of the same functionality with the addition of content authoring. The focus of a LCMS is the instructional content - its creation, reuse, management, and delivery. This contrasts with the logistics of managing learners, managing learning activities, and competency mapping provided by a LMS (Oakes, 2002). In other words, a LCMS focuses on the creation of learning objects (LO) while a LMS manages the learning process as a whole incorporating the LCMS within it (W. R. Watson & Watson, 2007). (Hall, 2007) states that 74% of LCMSs in their LCMS research report include LMS functionality. Both systems, however, manage and deliver instructional content usually in the form of LOs with a LMS being the more systemic of the two.

LOCM's Role with the LMS

The intersection between a LMS and a LOCM determines how a LMS delivers, communicates with, and manages content. As defined by the LOCM, a run-time environment (RTE) manages the content launch process as well as communication between content, the LMS, and the data model elements used for passing information relevant to the learner's experience with the content (ADL, 2006a).

As a LMS is a server-based environment with the capacity for managing and delivering content to learners, it determines what to deliver (content management), when to deliver it (sequencing), and tracks progress and performance as the learner moves through the instructional program (ADL, 2006a). This functionality is represented by the content management, sequencing, and the delivery services in Figure 1 - Functionality by

Service. LMSs may perform this functionality in a proprietary manner or be based on common standards and specifications that support interoperability and greater reuse of content.

For the purposes of this study, this discussion will focus on functionality pertaining to common interoperability standards and specifications. In this context, the described LMS functionality is performed by interacting with the manifest of a content package and with the content itself through a RTE. The manifest, content package structure as represented by the manifest, the learning/content objects structure, and the learning/content objects communication model are all defined by the LOCM in use. Based upon the LOCM, there are also specific behavior expectations embedded both within the LMS and the content. For example, a SCORM conformant LMS operates with the behavioral expectations imposed upon it by SCORM. In this way, the LOCM is the mediator between the LMS and the actual instructional content presented to the learner.

The concept of launching content refers to serving a learning or content object to the learner's Web browser (i.e., launch). The LMS knows what content to launch by reading the manifest describing the content package. The content package is a collection of learning content in the form of learning objects (shareable content objects in SCORM lexicon) and other web-based resources along with a XML file called a manifest (ADL, 2006a; IMS GLC, 2005) . A content package bundles learning/content objects or aggregations of learning/content objects together with a discrete content organization. A SCORM content package may represent a course, lesson, or module. It may also be a simple collection of related content (learning) objects. The manifest is an essential part of all content packages and is similar in many ways to a "packing slip." It lists the contents of the package and may include an optional description of the content structure (ADL, 2006a). The manifest form and its required content are defined by the standards and specifications making up the LOCM in use as in SCORM or IMS. However, in a proprietary nonstandard LOCM, this definition could conceivably take on any form desired as long as the LMS knows what to expect.

To determine when to launch the appropriate content, the LMS processes externally defined sequencing rules specified by an instructional designer and usually implemented by a developer. In SCORM, these rules exist as embedded logic within the manifest and define content behavior through the use of groups of content objects called activities and sub-activities. When the appropriate content object is determined, it is then served to the learner's web-browser where it is opened and ready for use by the learner.

The LMS communicates with content through a run-time service (RTS) (IEEE, 2004) also known as a run-time environment (RTE) (ADL, 2004b). It is typically provided by the LMS and usually but not exclusively exists on both the LMS and the learner's web browser (IEEE, 2004; Ostyn, 2007). The RTE on the learner's web browser then communicates with the shareable content object (SCO) through an application programming interface (API) instance and what has become known as a CMI (computer managed instruction) data model. The CMI data model evolved from the AICC CMI data model into an IEEE standard: IEEE 1484.11.1-2004 (IEEE, 2005; Ostyn, 2006) and is the basis for the SCORM CMI data model as part of its Run-Time Environment. Using this combination, data communicated to the LMS can represent such things as bookmarks, completions, scores, and mastery levels. Data can also be communicated from the LMS to the content object and, using the SCORM CMI/IEEE 1484.11.1-2004 data model, there are 24 categories of data overall, each with one of more data elements.

Interoperability Standards for E-Learning

Introduction

Standards are considered a vehicle for the sharing of knowledge, technology, and good practices. They are also considered an essential component of the world-wide industrial and post-industrial infrastructure supporting sustainable development (International Standards Organization [ISO], 2007b). Standards can be defined as agreements about technical specifications or other precise criteria. These are intended to be used consistently as rules, guidelines, or definitions of characteristics ensuring that materials, products, processes, and services are fit for their purpose (Friesen, 2005). When products and services meet user expectations, the role of standards is usually taken for granted but are soon noticed when they are absent. In the absence of standards, products may be of poor quality, fail to fit, be incompatible with equipment already owned, and/or be unreliable or dangerous. When products, systems, machinery, and devices work well and safely, it is often because of the standards they meet. "Standards ensure desirable characteristics of products and services such as quality, environmental friendliness, safety, reliability, efficiency and interchangeability - and at an economical cost" (ISO, 2007b, p. 1).

The key role of standards and the importance of standardization activities are increasingly recognized in education programs covering a broad variety of technical fields. These institutions are supported by prominent standards organizations such as the International Standards Organization (ISO) (ISO, 2007a). In the context of online learning, standards are generally developed for use in systems design and implementation for ensuring interoperability, portability and reusability. These attributes are intended to apply to systems (i.e. LMS) and the content and metadata they manage (Friesen, 2005).

E-Learning Standards

There are multiple organizations that contribute to e-learning standards. Prominent and most influential among these organizations are the IMS GLC, the AICC, the Learning Technology Standards Committee (LTSC) of the IEEE, the ISO, and the International Electrotechnical Commission (IEC). The latter two formed a joint technical committee called the JTC1 to focus on information technology (IT) standards. As a subset of the JTC1, the Standards Committee 36 (SC36) was formed to focus on e-learning. Of these organizations, IMS and AICC contribute only to specifications while the IEEE LTSC and the ISO/IEC JTC1 SC36 both focus only on standards development (Friesen, 2005; Olivier & Liber, 2003). Other organizations contributing to specifications especially in metadata are the Dublin Core and ARIADNE (Olivier & Liber, 2003). To date, two of the most prominent e-learning standards – the LO metadata standard and the CMI data model standard have both come from the IEEE LTSC (IEEE LTSC, 2005).

Standards development encompasses three main areas. These areas are specifications, implementations/reference models, and standards. The standards development process moves in cycles through research and development activities, user needs assessments and implementations, and standards approval. Implementations and reference models refer to the way they are applied in various communities and are sometimes referred to as application profiles (Friesen, 2005).

World-Wide Web Specifications, Standards, and E-Learning

Standards and specifications as implemented in a LOCM are designed to allow learning objects to be launched (started within a web browser) and to communicate data with a LMS in an interoperable fashion. However, for this interoperability to occur, there are other levels of interoperability that is relied upon. Web pages are interoperable because most web browsers conform to World-Wide Web Consortium (W3C) specifications (W3C, 2007c) and other standards. This ensures the same page viewed in Microsoft Internet Explorer (IE) can usually be viewed through Firefox Mozilla, Opera, or other W3C conformant web browsers with little change in user experience. The underlying web specifications and standards that allow for this interoperability and support the interoperability of learning or content objects include but are not limited to the document object model (DOM) specification (W3C, 2005) and ECMAScript standard. ECMAScript is the standardized version of the JavaScript programming language standardized by the European Computer Manufacturers Association (ECMA) (European Computer Manufacturers Association [European Computer Manufacturers Association [ECMA], 2005).

The standardization and accessibility of web browsers facilitate the use of browser-based technologies as the delivery mechanism du jour in online learning (Swinski & Williams, 2004). Web browsers are routinely addressed for maintenance and upkeep by system administrators of educational learning labs (Adie & Mark Ritchie, 2005). Their prevalence and interoperability combined both exhibits and implies standardization and de facto standardization (Olivier & Liber, 2003) from both the web browser developers and web page designers/developers. In the online learning field, the latter is typically done by instructional designers or instructional technologists. Although ubiquitous for over a decade, the current high level of interoperability was not always the case as over the years designers have had to design for either specific web browsers (i.e. Netscape or IE) or design to a lowest common denominator severely limiting the user's browsing experience.

SCORM 2004

Shareable Content Object Reference Model or SCORM is a web-based learning content aggregation model and run-time environment for learning objects (ADL & UK, 2007). Initiated by the Advanced Distributed Learning (ADL) program of the Department of Defense (DoD) and the White House Office of Science and Technology Policy (OSTP) (ADL, 2006a), SCORM now has approximately 193 adopters globally and is supported by a technical working group of over 70 members. It has gained world-wide acceptance and is poised to transcend from the sole support of ADL to a global stewardship organization (adlCommunity, 2007a).

Introduction

Essentially a reference model in its sixth release state, SCORM is a model that references a set of interrelated technical specifications, guidelines, and standards designed to meet the DoD's high-level requirements for e-learning content (ADL, 2004b). SCORM is recognized as a learning object content model or LOCM (Katz et al., 2004; Verbert et al., 2005; Verbert & Duval, 2004; Verbert et al., 2004) and was one of the LOCMs used in Verbert et al's comparative analysis of LOCMs (Verbert & Duval, 2004; Zouaq et al., 2007) with a shareable content object (SCO) described as a learning object. In the context of SCORM, ADL envisaged Internet users and heterogeneous

LMSs using the Web as a universal platform for accessing and launching sharable content objects and for establishing close communication, interaction, and coordination among content object developers, course authors, content users, and course administrators (Su & Lee, 2003).

Technical Architecture

SCORM was designed to facilitate heterogeneous web-based LMS to interoperate, access common repositories of executable content, and launch content that is authored using tools from different vendors (ADL 2001a). From its inception until version 1.2, SCORM has been based upon a technical architecture composed of a Content Aggregation Model (CAM) for aggregating learning resources to form learning modules and courses and a Run-time Environment (RTE) for launching learning resources and enabling the communication between learning resources and Learning Management Systems (LMS).With the evolution to SCORM 2004, the architecture expanded to include sequencing and navigation (SN) functionality.

Using common standards and specifications as well as custom models, SCORM 2004 3rd Edition has incorporated the IEEE Standard for Learning Object Metadata (IEEE LTSC, 2005), a SCORM Content Aggregation Model (CAM) (ADL, 2006d), the IEEE ECMAScript API for Content to Runtime Services (IEEE, 2004), the IEEE Data Model for Content to Learning Management System Communication (CMI data model) (IEEE, 2005), the IMS Content Packaging Specification (IMS GLC, 2005), the IMS Simple Sequencing Specification (IMS GLC, 2003a), and a SCORM Navigation Model (ADL, 2006c) (Ostyn, 2007). With the release of SCORM 2004 3rd Edition, the use of the IEEE LOM is recommended but not required for SCORM conformance (ADL, 2006e).

Using these specifications and standards, the SCORM specifies how reusable web-based content objects called shareable content objects (SCO) can be aggregated into a portable package that includes a manifest to form a larger self-contained content object (Ostyn, 2007). The manifest includes metadata to describe each level of the aggregation as well as prescriptive data defining the sequencing or order of content accessibility. The types of objects that can be described and utilized as a content package are outlined in the SCORM CAM as Assets, SCOs, and Content Organization (activities). Within the SCORM nomenclature, Assets and SCOs are both considered Resources. Activities are considered learning activities. An Activity Tree represents the data structure that an LMS implements to reflect the hierarchical, internal representation of the defined learning activities. Content Organization represents an Activity Tree describing the organization and sequencing of Items (Activities and Resources) (ADL, 2006c).

Content Aggregation Model

The term “Content Aggregation” can be used as both an action and as a way of describing a conceptual entity. “Content Aggregation” can be used to describe the action or process of composing a set of functionally related content objects or, in terms of the SCORM Content Model, a Content Aggregation is also used to describe the entity created as part of this action or process. The term is also used informally to describe the content package. The Content Aggregation can then be used to deliver the content and prescribed content structure, transferred between systems or even stored in a repository (ADL, 2006d). The Content Aggregation Model (CAM) is the set of object descriptions and specifications allowing the creation of a Content Aggregation.

According to the SCORM 2004 CAM book, Assets, the basic building blocks, are an electronic representation of media, such as text, images, sound, assessment objects, or any other piece of data that can be rendered by a Web client and presented to a learner. Assets can be collected together to build other assets and may be launched independently if necessary. Using the IEEE LOM or other defined schema, Assets can be described with metadata for search and discovery (ADL, 2006d).

A SCO is a collection of one or more Assets representing a single, launchable learning resource (i.e. learning object) that can communicate with a LMS using the run-time environment, and be described by metadata for search and discovery. SCOs communicate with a LMS using the IEEE ECMAScript API for Content to Runtime Services Communication standard and are the lowest level of object tracked by a LMS using the SCORM Run-Time Environment Data Model (i.e. CMI data model). The communication and tracking functionality together are the basis for the SCORM RTE. An illustration depicting the conceptual makeup of a SCO and its component Assets is presented in Figure 2 below.

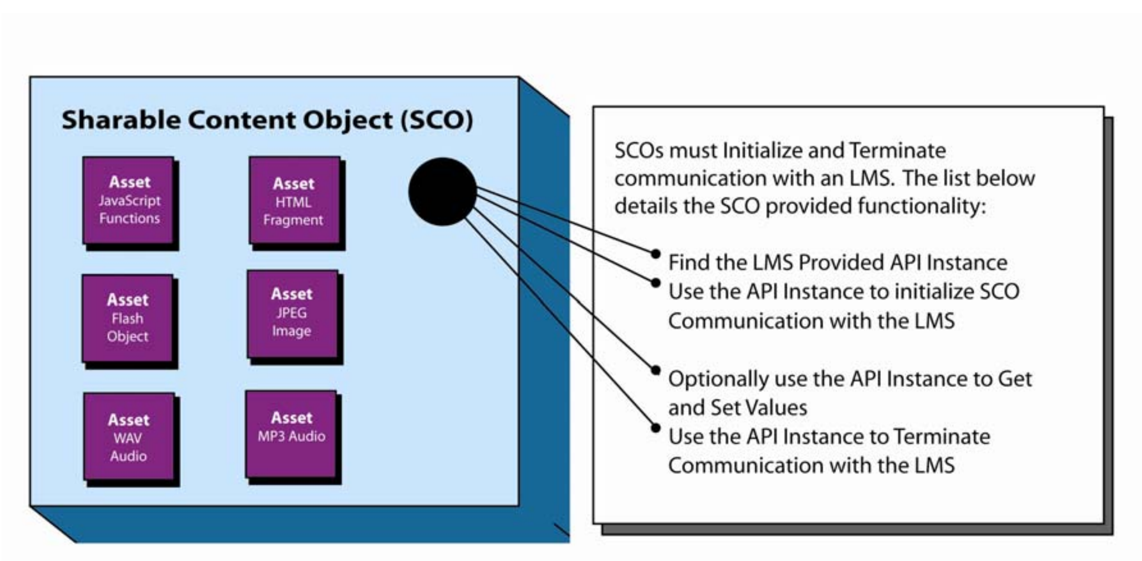


Figure 2. Conceptual Makeup of a SCO (ADL, 2006d)

There are specific expectations and requirements of a SCO by the RTE. This implies that a SCO must be able to locate an API Instance provided by the LMS and must invoke at a minimum the API methods *Initialize* and *Terminate*. There are, however, no requirements to use any other of the API methods, and they are usually only implemented as required by the learning content. The reasoning behind forcing a SCO to utilize the RTE actually lies with the LMS. By having content that behaves in a standardized fashion, and with the tracking and management capabilities of the RTE, the following gains can be realized:

- Any LMS that supports the SCORM RTE can launch SCOs and track them, regardless of where they originated.
- Any LMS that supports the SCORM RTE can track any SCO and know when it has been started and when it has ended.
- Any LMS that supports the SCORM RTE can launch any SCO in the same way.

ADL loosely describes an Activity as a meaningful unit of instruction and is what the learner does while progressing through instruction. As described in SCORM, an Activity may provide a learning resource (SCO or Asset) to the learner or it may be composed of several sub-activities. Activities may be nested in multiple levels and consist of other Activities or sub-Activities, which may themselves consist of other activities. There is no set limit to the number of levels of nesting for Activities.

Although activities are often associated with educational levels such as a unit, module, or course, these levels are not a requirement for SCORM. If an Activity does not consist of other Activities, it will have an associated learning resource (SCO or Asset) that is used to perform the activity. A resource is launched when an activity that references that resource is started (Ostyn, 2007). Multiple activities can reference the same resource. As with the other levels of aggregation, each Activity in a Content Organization (i.e. complete collection of activities and learning resources in a package) can reference metadata to allow for search and discovery (ADL, 2006d).

Sequencing of learning content by the LMS only applies at the Activity level (ADL, 2006d). Through the use of the IMS Simple Sequencing specification, SCO and Asset sequence rules can be defined in the Content Organization and applied at run-time. Sequencing also allows for a limited variable defined as an objective status that can be tracked within a defined sequence (ADL, 2006c). Typically, when a SCO is launched, the tracking data provided can influence the result of sequencing rules. For example, a passing score for a SCO may result in skipping some other activity (Ostyn, 2007).

Run-Time Environment (RTE)

One of the most essential functions of SCORM is that of communicating with a LMS. What performs the communication is defined by the CAM. The RTE and, to a lesser degree, the Sequencing and Navigation model (SN) defines how and when communication occurs. However, by defining how and when communication occurs, limits are naturally imposed. The inability to launch and maintain persistent SCOs, no direct SCO to SCO communication, and the CMI data model are some of the limits imposed with potential limiting effect. The RTE contains three components: the Launch model, the API, and the RTE (CMI) Data Model. The Launch Model and the API are closely related and are discussed together in the following section.

Application Programming Interface (API). "In its simplest terms, the API is merely a set of defined functions that the SCO can rely on being available" (ADL, 2006b, pp. RTE 3-4). The RTE is based upon a client/server relationship and is shared between both the server (LMS) and the client (web browser). It relies on an instance of the API object (i.e. API) provided by the LMS and instantiated in the document object model of the web browser (ADL, 2006b). The SCO is required to locate the API object upon launch establishing communication with the LMS (ADL, 2006b). For the connection to occur, the LMS must make the API object available in the DOM (Document Object Model) context of the web browser before it launches the SCO. The SCO must then look for an instance of this API object by searching frames and windows in a very specific order defined by the IEEE standard. Once the SCO has found the object, it calls methods (functions) of the object to start a communication session with that object (Ostyn, 2007).

The sharing relationship and the API's place is illustrated by the SCORM RTE Conceptual Model in Figure 3. The actual architecture and the relationships between the component including the SCO and Assets are clearer in the SCORM Run- Time Environment Figure 4 from *In the Eye of the SCORM* (Ostyn, 2007).

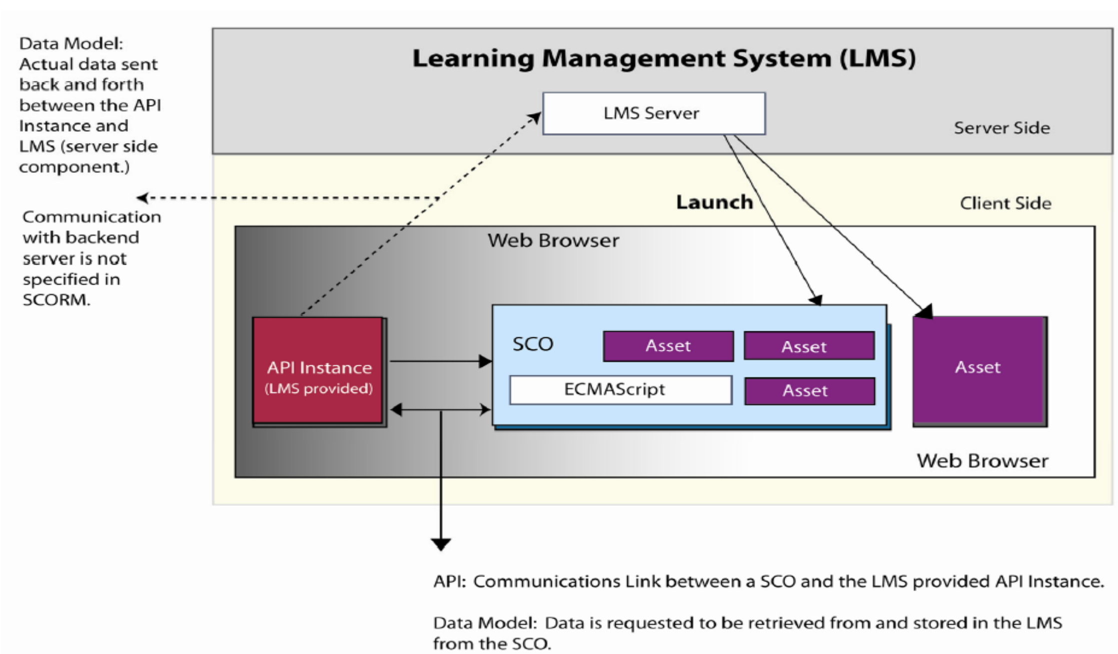


Figure 3. SCORM RTE Conceptual Model (ADL, 2006b)

A SCO initializes a communication session by calling the corresponding method or function of the API instance. After the session has been successfully initialized, a SCO can get and set data (send and set a variable) to and from the LMS through corresponding methods or functions of the API instance. To end the session, a SCO must terminate the communication session by calling the corresponding function. There is only one communication session allowed for every launch of a SCO by the runtime environment. An error will be caused if a SCO tries to initialize a new communication session after terminating the session (ADL, 2006b; Ostyn, 2007). In effect this means that only one SCO can be launched at a time.

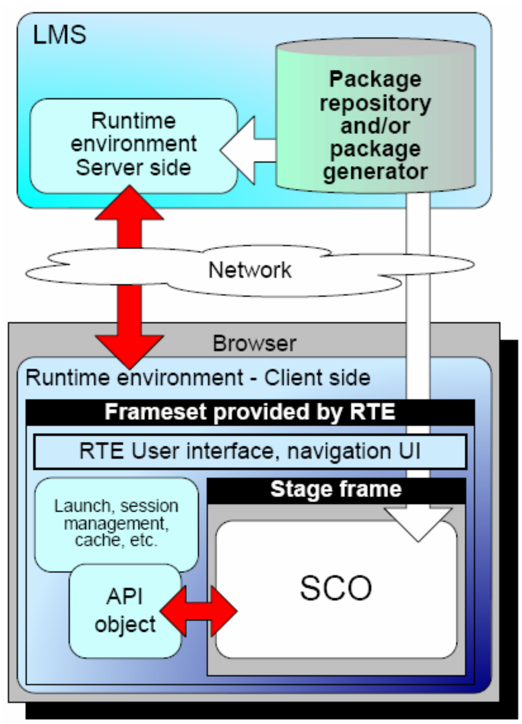


Figure 4. SCORM Run-Time Environment (Ostyn, 2007)

Within an API instance, there are eight functions divided into three broad categories that can be called. These include functions for launching and terminating a SCO called Session Methods, functions for exchanging data model values between a SCO and a LMS called Data-transfer Methods, and functions for auxiliary communications such as error handling call Support Methods (ADL, 2006b). These functions are illustrated below in Figure 5.

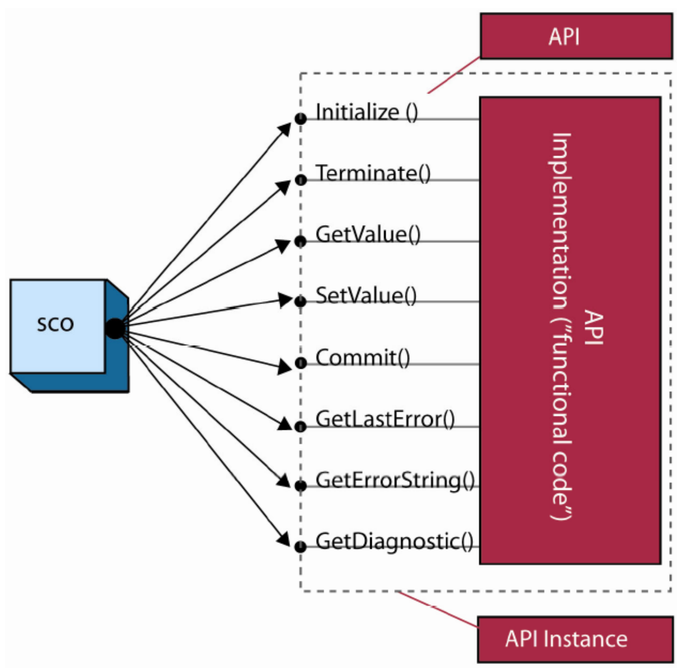


Figure 5. Illustration of API, API Instance and API Implementation (ADL, 2006b)

RTE Data Model. The CMI communication data model defines the data that can be sent back and forth between a SCO and the LMS using the API. Each data element is specified whether the data contained within it can be retrieved by a SCO from the LMS or sent from a SCO to the LMS or both. Data retrieved from a SCO include requests about how it is being launched, other initialization data, and learner data. Data used as signals, markers, or requests to the RTE, such as the time elapsed in the SCO or SCO suspend data requests, are sent from the SCO to the LMS. However, most of the data elements defined in the CMI data model may be retrieved or sent. Score data may be sent to the LMS which is sent back later in the same communication session or data describing an existing objective status for a particular learner may be updated and sent to the runtime environment to facilitate LMS tracking or sequencing of content (ADL, 2006b; Ostyn, 2007). Figure 6 illustrates the API's role in implementing the RTE Data Model.

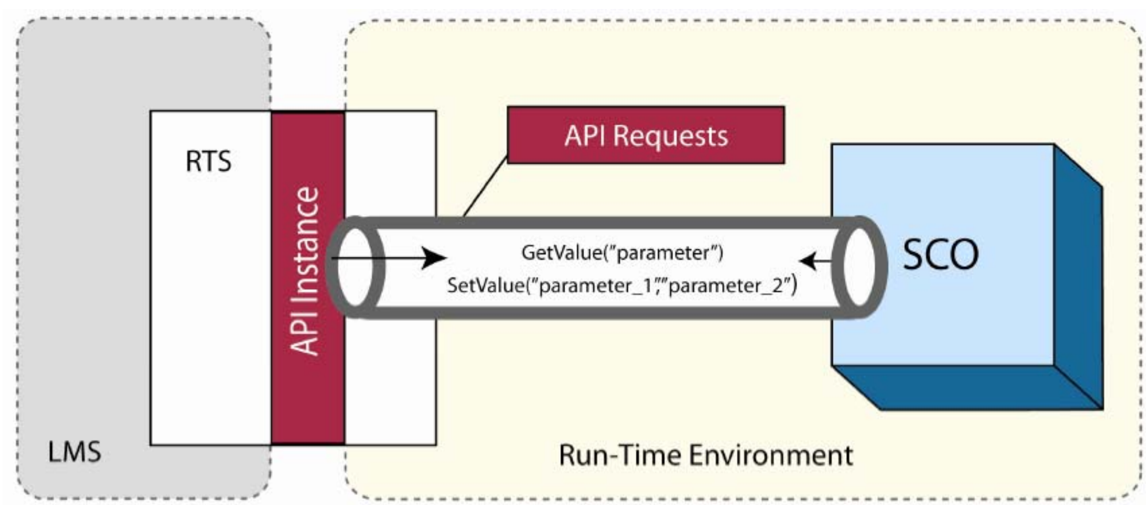


Figure 6. Illustration of Using the Data Model with the API (ADL, 2006b)

There are 24 main data elements defined within the CMI data model. SCOs are not required to implement every data element, but they must all be implemented by the RTE (Phelps, 2004). These elements represent several data categories that support specific SCO/LMS functionality. The categories have been characterized as:

- SCO status, including completion and success status,
- Score data,

- Score thresholds,
- Objective data and object status data,
- Data about various types of interactions and their status and learner responses,
- Comments,
- Limited learner information,
- Common learner preferences,
- Suspend data and location (used for bookmarking), and
- Entry and exit status (Ostyn, 2007).

Sequencing

Sequencing defines a method for representing the intended behavior of designed learning activities, allowing any LMS to sequence discrete learning resources in a consistent manner (ADL, 2006c). The Sequencing Definition Model allows a learning activity to be defined as an activity tree (a hierarchical organization of learning content) having sequencing control modes associated with its items, called Activities (ADL, 2006c; Su & Lee, 2003).

Using Activities, sequencing functionality is designed to allow instructional designers to define the manner in which a learner accesses SCOs and allows a designer to specify what is presented to a learner, when it is presented, and the attributes or functions the SCOs entail. Sequencing is also designed to track the learner's choices and performance (LSAL, 2004). This functionality is defined in the Sequencing Tracking Model (ADL, 2006c).

As SCORM does not permit one SCO to "call" or access another SCO directly, through sequencing the LMS controls the movement of the learner from SCO to SCO. This control described as "branching" is based upon behaviors defined by the designer.

The resulting sequencing rules are a part of the manifest in the “organization” element and read by the LMS at run-time. This functionality allows the same set of SCOs to be sequenced in many different ways, depending upon the designer and the learner (LSAL, 2004).

Implicit objectives exist within the design of every activity and, if they are explicated, success in achieving that objective can be recorded. Sequencing allows the implicit objective for an activity to become explicit and to map it to other objectives associated with other activities in the activity tree (LSAL, 2004). To accomplish this, sequencing uses a global variable called an objective. For sequencing purposes, the objective global variable allows the LMS to share status values between SCOs. Depending on a designer’s needs, the objective may or may not track actual learner objectives, skills, or abilities.

The objective refers to the method that a SCO can pass two types of MasteryStatus parameters to the LMS: PassFail and NormalizedScore. The criteria the SCO will use to report these parameters are determined by the designer. The PassFail data type reports only true or false values and the NormalizedScore reports a value for an OBJ (objective) to any decimal value between −1 and +1. Either parameter can have values set based on a response to a single question, a complete assessment, or simply whether the SCO has actually been viewed. It is possible to set or read multiple objectives by any SCO, and it is possible to set or read a single objective by multiple SCOs (LSAL, 2004).

LMSs read sequencing data represented by an activity tree - an instance of hierarchical learning activities and specified sequencing behaviors. An activity tree is a static structure that represents the data structure that an LMS implements to reflect defined learning activities. The activity tree is defined within a SCORM manifest as a Content Organization or, more simply, the organization. The organization contains one or more activities that can be nested to any depth as sub-activities (ADL, 2006c).

As the content structure and the method or sequence that a learner is expected to access is represented by the activity tree, the tree can either be a parent activity in a cluster of sub-activities or a leaf activity with no children. Leaf activities reference a resource launched when the activity has begun. A leaf activity may reference only a single resource (Asset or SCO). (Ostyn, 2007).

For sequencing to occur, there must be a defined structure of learning activities, the activity tree; a defined sequencing strategy, the Sequencing Definition Model; and the application of defined behavior to external and system triggered events, and SCORM Sequencing Behaviors (ADL, 2006c). A unit of learning defined by an activity tree is static in as much as it has a fixed structure, predefined control modes, and sequencing and roll-up rules, which are to be followed by a LMS occurring for each and every enactment of the tree (i.e. all instances of its processing) (Su & Lee, 2003). To successfully design the activity tree, sequencing strategy, and the sequencing behaviors requires the creation of a content structure diagram (LSAL, 2004).

Content structure diagrams as a means of facilitating sequence design can be constructed as templates and reused. These templates can be based upon useful and common instructional processes such as a remediation process or different types of branching conditions (LSAL, 2004). Templates can also be made to embody combinations of proven learning patterns (Ostyn, 2007) or even instructional strategies or pedagogical models.

According to the Learning Systems Architecture Laboratory (LSAL, 2004), “Any template or combination of templates can be ‘overlaid’ on or combined with another template, creating a more complex instructional strategy for a course or a lesson. Combining the templates …will give you viable sequencing models that you can adapt to meet your particular training and educational requirements” (p. 8).

Perceived Limitations

Even though SCORM in its ubiquity may be developing into a de facto standard (Olivier & Liber, 2003), it is seen as being limited in many areas. Although it is self-described as focusing on individual self-directed learning (Dodds & Fletcher, 2004; Kraan & Wilson, 2002), this is seen as a limitation for collaborative learning models which have taken hold and are dictating new work in developing collaboration SCOs and services within the SCORM environment (Ip & Canale, 2003; Oliver & McLoughlin, 2003). The use of learning models other than those that are content centric or based on intelligent tutoring within the SCORM environment is seen as limited and, consequentially, new models are emerging (Conlan, Wade, Bruen, & Gargan, 2002; Harper et al., 2005; Oliver & McLoughlin, 2003; Olivier & Liber, 2003). Zoaq et al question the robustness of the IEEE LOM and SCORM’s lack of support for Semantic Web technologies (Zouaq et al., 2007). In discussing the limitations of sequencing, Su and Lee (2003) state that the static nature of the activity tree

> … is not ideal because different content users may take the module
> or course with different background training, in different learning

> contexts and constraints, and for different needs (e.g., different background trainings require different difficulty levels or different orders of content delivery, or some component may be skipped due to a learner's previous knowledge). It is unreasonable to expect that an activity tree can be predefined by a content developer to suit the different needs and constraints of all potential learners. An activity tree can only represent a "typical" structure of learning for a group of potential learners. It has to be customized to meet individuals' needs, constraints and learning contexts. (Su & Lee, 2003, p. 3)

Pedagogical Models

The definition of pedagogical model differs depending on the context in which they are discussed. In the context of learning theories, Driscoll discusses pedagogical models alongside conceptual and mental models as a part of schema theory. In this context, they are models built upon students' models of the world in order to help in understanding. In this sense, pedagogical models are a tool to provide "…strategies for helping learners make predictions from and debut their current models of understanding (Driscoll, 2000, p. 147)." Grimmitt states that the selection of curriculum content and the choice of methodology (or methodologies) selected for their ability to bring about learning outcomes as components of designing constitutes a pedagogical model. He also states that a pedagogical model should deploy specific pedagogical procedures or strategies which determine how learners will experience, engage with, and respond to the content (Grimmitt, 2000).

However, a recent trend is for designers of online learning to look at reusable models or designs of learning embodying specific instructional theories and related strategies as separated from specific learning resources (Oliver & McLoughlin, 2003). Research is also focusing on the application of model-based development or engineering to instruction. Sallaberry et al are using the Unified Modeling Language (UML) to develop pedagogical models based upon problem-based learning (PBL) as a basis for a global reusable information system to support learning (Sallaberry, Nodenot, Laforcade, & Marquesuzaa, 2005). These models or designs are thought of as components of reuse incorporating other reusable resources such as learning objects (Gallagher, 2005; Oliver & McLoughlin, 2003).

The predominant approach to online learning and the LOCM that support it is focused on a content-based pedagogical model or as content-centered approaches to learning (Oliver & McLoughlin, 2003). This model essentially provides content presentation as the means to transmit knowledge from the content to the learner. Content-centered models have evolved because content is relatively easy to author and manage through information systems (IT) such as content management systems (CMS) and LCMS. These systems work well with a tangible chunk of content that can be easily described as an object with specific defining attributes (W. R. Watson & Watson, 2007).

Contrasting the content-centered model is that of goal-based models. These include models built upon inquiry-based learning, problem-based learning, case-based learning, and other models where learners participate in active learning experiences (Oliver & McLoughlin, 2003). These models place more emphasis on learning activity designs instead of content transference (Koper, 2003). Currently, these models are supported by the Open University's Educational Modeling Language and the IMS Learning Design (Koper, 2003; Olivier & Liber, 2003).

Simulations

Definition

> In an educational simulation, much like a computer game, and of course in learning to ride a bike, swim, speak a foreign language, close a big deal, make a customer happy, or build something, that frustration-resolution can not be closed by passively consuming more. The frustration can only (and not even all of the time) be resolved by actively doing something. (Aldrich, 2006, p. 2)

Simulations model reality by various means and modes. According to Herz, if an object simulates something, it is a simulation (Herz, 1997; Prensky, 2001). Alessi (2000) described educational simulations as programs that incorporate learner-manipulated models accompanied with learning objectives for understanding each model. Others described simulations as synthetic or counterfeit creations, artificial worlds approximating reality, something that creates the reality of a workplace, or mathematical models that allow prediction and visualization over time (Prensky, 2001).

As illustrated by the many definitions, simulations are described by many terms and mean many things to many people whether designed specifically for learning or not. Prensky (2001) further defines simulations as a type of game with *game* being the addition of gaming structural elements. Simulations by themselves then are not always thought of as a complete interactive environment depending upon the purposes they are used for. Norton and Sprague (2001) discuss (computer) simulations as complex systems

“…in which programmers have embedded understanding of the structures or central concepts that govern a particular knowledge domain and an expression of the processes by which those structures interact” (p.168). Maier discusses the terms ‘‘learning laboratory’’ and ‘‘interactive learning environment’’ (ILE) as environments that usually contain more than a pure computer simulation model. They employ one or more simulation models embedded into a learning environment that may also include case descriptions, presentations by a facilitator and modeling tools (Maier & Grobler, 2000).

In virtually all domains, simulations have been researched and applied successfully to model real world processes, applications, and objects (Sulistio, Yeo, & Buyya, 2004) and, especially in education, have five characteristics in common. These characteristics include: a vision of knowledge including the structure and processes that occur within a domain; a foundation based on or around an authentic problem within the domain; a definition of a specific context or setting; decisions to be made or variables to be manipulated; and governance by a set of rules of interaction (Norton & Sprague, 2001).

Simulation Types

There are several descriptions and taxonomies developed to describe and classify simulations (Aldrich, 2006; Alessi, 2000; Maier & Grobler, 2000; Prensky, 2001; Sulistio et al., 2004), ranging from the very simple to the more complex. Sulistio developed multiple taxonomies based upon simulation attributes and components in distributed systems (Sulistio et al., 2004). Alessi describes simulations around their pedagogical use - using or building (Alessi, 2000). The most detailed taxonomy and the one used to classify the simulation for the purposes of this study is that of Maier and Grobler (Maier

& Grobler, 2000). It makes use of Alessi's prior work but adds modification and expansion which results in a comprehensive multi-tiered taxonomy based upon three main categories- underlying model, human-computer interaction, and functionality. Each of these categories is then broken down into two more levels with the actual attributes residing at the third level. The details of the taxonomy are shown in the table below (see Figure 7).

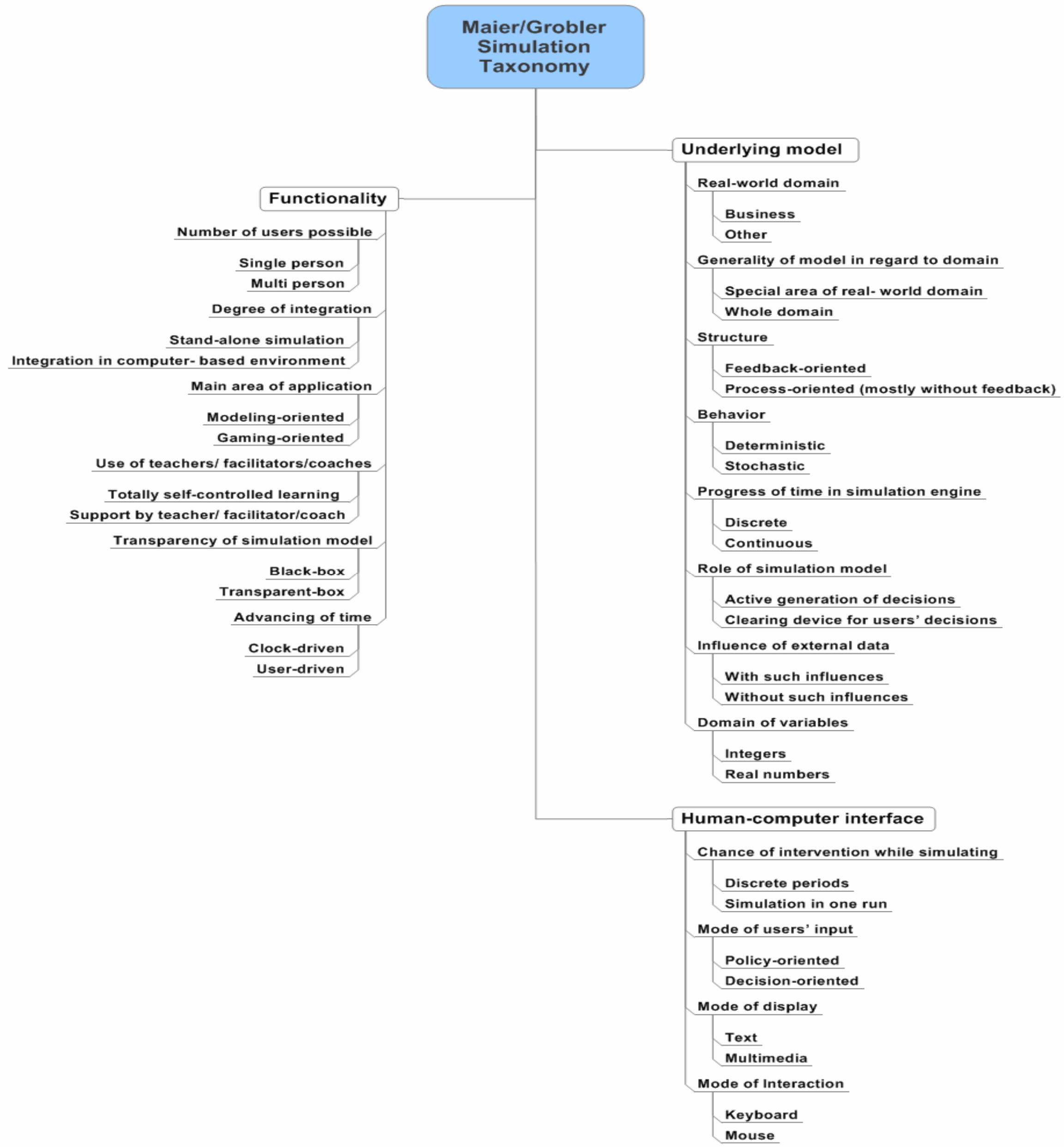


Figure 7. Maier/Grobler Simulation Taxonomy (Maier & Grobler, 2000)

As robust as this taxonomy appears to be, there are still missing attributes and assumptions that may or may not necessarily be true. For example, functionality nodes may not apply as indicated if the single person user type is actually a small group playing as one. Also, the assumption that a facilitator or coach is a human entity is strongly implied when it may actually be another component to the simulation. In addition, the degree of fidelity of the underlying model is not clear. It is of note, however, that in the overall model, depending on the category/level combination, either one or both characteristics may apply.

Simulation as a Pedagogical Model

In *Technology for Teaching*, simulations are considered unique instructional strategies that are consistent and repeatable in an instructional context (Norton & Sprague, 2001). Saunders (1997) described simulations as a cyclic learning process, and Saleh (2005) states that simulations remain one of the most efficient models of teaching. A pedagogical model is considered as having curriculum content and the choice of methodology (or methodologies) thought capable of bringing about learning outcomes through deploying specific pedagogical procedures or strategies (Grimmitt, 2000). A pedagogical model is also considered to be a model to help students understand and elicit their models of the world (Driscoll, 2000). In the context of instruction and in light of the previous descriptions and definitions, an instructional simulation can be considered a pedagogical model.

PharmaSim

Computer based simulations have become part of the pedagogy for learning and applying business concepts (Saunders, 1997) and, as with other simulations, are available online (Norton & Sprague, 2001). Online simulations exist in various modes and types from virtual environments teaching leadership such as Virtual Leader (Aldrich, 2004) to those aimed at teaching marketing. Simulations offer players the opportunity to experience the realism of making decisions in a learning environment. A prominent online simulation for the teaching of marketing business decision, for example, is PharmaSim (Interpretive, 2006). PharmaSim was developed by Stewart James in the mid 1990's and is located on the Web at http://www.interpretive.com/pharmasim. PharmaSim is a highly successful educational simulation currently in use by such business schools as Drexel and Darden (James, Kinnear, & Deighan, 1999).

The PharmaSim computer simulation primarily focuses on marketing activities. A participant (or team) will, therefore, be making decisions regarding product mix, pricing, distribution, advertising, and promotion. The starting situation as well as a description of the industry is introduced through the use of a case that serves as the introduction or context to the PharmaSim environment.

Description and Characteristics

PharmaSim is best described as a brand management simulation based on the over-the- counter (OTC) cold medicine industry. The goal of the simulation is to teach marketing concepts in an active and stimulating environment. In order to be successful in PharmaSim, players must perform a thorough analysis of external and internal marketing issues and devise and implement an appropriate long-term strategy. Learners need to identify target market segments, determine customer needs and buying behavior, analyze competitive strategy and tactics, and formulate an appropriate use of marketing resources based on their analysis (James et al., 1999).

The PharmaSim marketplace simulates the US market. Participants are asked to manage the highly profitable OTC cold medicine division of Allstar Brands, a large pharmaceutical company. Competition in the PharmaSim environment has been simplified to five firms each with different strengths and weaknesses. Currently, the Allround brand is the only cold medicine Allstar Brands has on the market. Historically, Allround has been number 1 or 2 in the industry and is highly profitable with excellent brand awareness. Each virtual year, participants make decisions on pricing, advertising, consumer and trade promotion, distribution, and sales force for the Allround brand (James et al., 1999).

As a member of the marketing management team, learners make decisions regarding product mix, pricing, distribution, advertising, and promotion. These decisions are incorporated into a computer-simulated market to reveal how they have performed. Decisions cover a time-span of up to 10 simulated periods, allowing players to observe both the short-term and long-term effects of decisions (Interpretive Software, 2006).

PharmaSim offers three playing levels with varying degrees of complexity. "Brand Assistant" has the fewest decisions and least number of reports available. "Assistant Brand Manager" is moderately complex. "Brand Manager" is the most complex and offers the greatest detail in decisions. The simulation also has multiple scenarios with varying degrees of difficulty (Interpretive Software, 2006).

As the simulation progresses, new issues and problems arise. In the second decision period, participants are able to reformulate the Allround brand. After several more periods, they have the opportunity to create a line extension of the Allround brand. Later, players have the option of introducing a brand in the over-the-counter market which was previously prescription only. Along with having to manage more than one brand, participants are also given more control over marketing mix decisions as the game progresses. For instance, learners have the ability to target advertising and consumer promotion to particular customer segments, target trade promotion and sales force to different distribution channels, and offer price discount schedules based on volume (James et al., 1999).

Based on these characteristics PharmaSim could be categorized on Maier's taxonomy as described by the terms on the following taxonomy tree (see Figure 8). To find an applicable characteristic, go to the last dependent element of each branch. For example, under *Functionality* the category *Number of users possible*, the last dependent element is *Single person*.

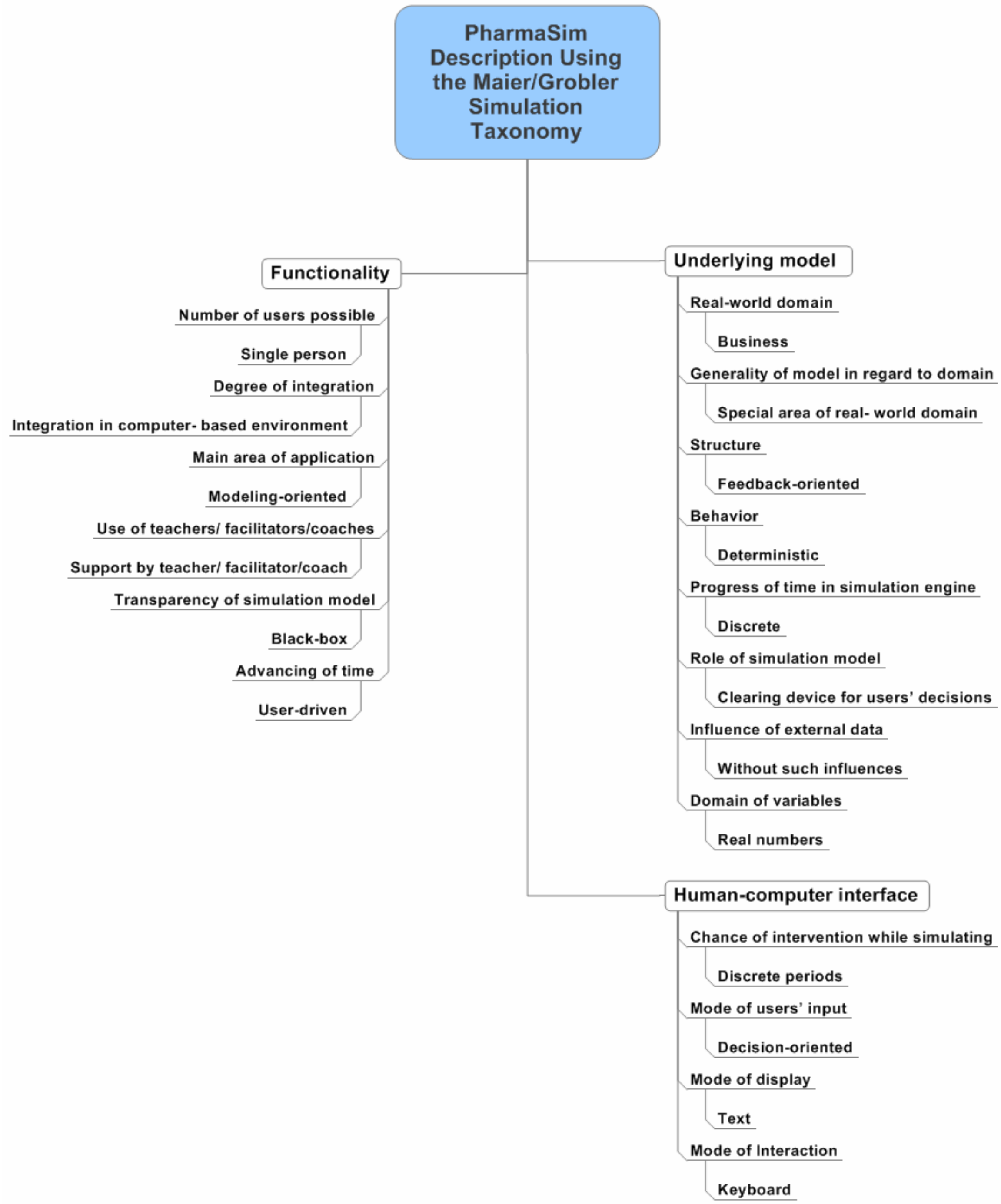


Figure 8. PharmaSim Characteristics from Taxonomy

Use-Case for Requirements Development

A use case is a contract between stakeholders of a system about its behavior. It is a description of the system's behavior as the system responds to a request from one of the stakeholders. A stakeholder is considered someone with a vested interest in the system under discussion (SUD). Use cases are primarily text-based but can be written using other means and consist of goal statements concerning the scope (what), the primary actor (who) and the goal level (high or low) (Cockburn, 2001). Use-cases are often diagramed, providing a functional description of a system and its major processes (Hay, 2003).

The user goal is of greatest interest (Cockburn, 2001) in defining system requirements and is the focus of designing use cases. However, it is very important to understand which goals being described are actually at the user level as some are actually summary goals and others are sub-functions. To denote a true user-level goal, it should address the question, "Can the primary actor go away happy after having done this?" Other questions that may speak to a user-level goal include, "Does your job performance depend on how many of these you do today?," or "After I get done with this, I can take a coffee break." Usually a goal passes the one person one sitting test (Cockburn, 2001) for task accomplishment.

One way of understanding and mapping the true user-level goals is through a use case level diagram. This is a network diagram much like a concept map that graphically maps goals and goal connections both vertically and horizontally. The higher up a goal is the more of a summary function is has. The lower down a goal is the more of a sub-function it is. In these diagrams, vertical location is denoted by an analogy to the sea or ocean. The higher up in the diagram the closer to the "air" and the lower down the closer to the “sea floor.” Where the air meets the sky is considered “sea level” and are located in the vertical center. Graphically, the user-level goals are those mapped at sea level (Cockburn, 2001). This technique can be applied to a series of use cases to determine goal levels and what truly is the use-level functionality of concern.

3. Research Methods

Research Design

Research designs are currently recognized to fall within two broad categories: fixed and flexible. Fixed research designs include experimental and non-experimental types with sub-types which includes relational, comparative, and longitudinal (Hutchinson, 2004; Robson, 2002). Fixed research designs may be either quantitative or qualitative in nature or both depending on the type and research questions developed. However as fixed research designs are theory driven and initially require a solid conceptual framework and variable definitions, the tendency is for fixed designs to be quantitative in nature (Robson, 2002). Flexible designs on the other hand tend to be primarily qualitative and include case studies, ethnographies, phenomenological research, hermeneutic studies, and design research (Kelly, 2004).

This research uses a fixed and non-experimental design in order to describe the current state of a phenomenon. There was no intentional variable manipulation by the researcher. The research also falls into the sub-type of relational designs as it examines the relationships between two or more variables. Specifically within the relational sub-type, this design is a cross-sectional study focusing on relationships between variables of a single group with all measures roughly being taken during the same time frame and employing a survey method of data collection (Robson, 2002).

As the ultimate aim of this study is to facilitate the improvement or development of SCORM as a LOCM, this design also falls within the genre of developmental research. Developmental research is an emerging research genre that blends theory and practice and is directed toward both the improvement of practice and the enhancement of the knowledge base in the field of instructional design and technology. As such, developmental research involves producing knowledge for process improvement in instructional design, development, and evaluation (Richey et al., 2004). Typically, methods employed in developmental research can be either qualitative and/or quantitative (Seitz, 2004) and can use most all accompanying data collection strategies.

As a genre, developmental research falls into two main types: Type 1 and Type 2 (Richey et al., 2004). Type 1 is concerned with the development of a specific product, the results are usually context and product specific, and it is not concerned with the overall process. Type 2 is concerned with the improvement of design, development and evaluation processes, rather than a demonstration of such processes. The ultimate goal is to design or development of new procedures or models. The key difference between Type 1 and Type 2 studies is that focus on a particular aspect of the total process tends to be more generalized, striving to enhance the ultimate models employed in these procedures. Type 1 research, on the other hand, is more confined to the analysis of a given project (Richey et al., 2004).

In its overarching goal, the design of this study crosses over from Type 1 to Type 2 within developmental research (Richey et al., 2004). It is Type 1 in as much as its purpose is to evaluate and improve a specific product (SCORM 2004) and it is Type 2 because of its far reaching and general implications of improving or re-designing an ubiquitous LOCM (SCORM 2004).

As the goal of this study is to assess SCORM for gaps in its affordances necessary to facilitate using simulations as a pedagogical model, this study also could be considered a gap analysis and as such also fits within the genre of evaluative research in determining needs or deficiencies of existing programs or interventions (Cohen, Manion, & Morrison, 2000; Robson, 1993).

In information technology, a gap analysis is the study of the differences between two different information systems or applications, often for the purpose of determining how to get from one state to a new state. A gap is sometimes spoken of as the space between where we are and where we want to be with the states also referred to as the “as is” and the “to be.” The purpose of a gap analysis is to decide how to bridge that space (SearchSMB.com, 2006).

In the field of instructional technology and design, a gap analysis is a crucial component of the analysis phase in the mostly linear ISD development model consisting of analysis, design, development, implementation, and evaluation phases and labeled the ADDIE model of design and development or ADDIE. As the principle model of the instrumental paradigm of instructional design (Visscher-Voerman, Gustafson, & Plomp, 1999), ADDIE concentrates on the design needs of instructional systems with the basic approach beginning with a problem and needs analysis resulting in concrete design goals and objectives. Within this model, a gap analysis usually occurs as a performance analysis or front-end analysis used for identifying the nature of a problem.

Gap analyses use the terms “what is” and “what should be” for identifying existing and ideal states of a system. More formally, however, the “what is” is called the condition, the “what should be” is called the criterion, and the difference between the two is called the gap. The reason for the gap is called the “cause” and its consequences are referred to as the “symptoms” (Rothwell & Kazanas, 1998). This study made use of the gap analysis methodology by assessing the condition or existing state known as SCORM 2004 against a developed criterion known as the SIMREF to identify the gaps between the states, their causes, and their symptoms. In summary, the design of this research is a fixed relational cross-sectional study. It is also Type I and Type II developmental and evaluative research employing a formal gap analysis methodology using survey methods as its primary data collection strategy.

Research Questions

To focus the evaluation process and facilitate analysis, the research must be guided by the specific research questions in the design. This guidance ensures alignment of the evaluation targets with the indicators and procedures necessary to achieve those targets. These questions were presented in Chapter I and are reiterated here to help clarify the research design:

1. Are functional or typed SCOs necessary to fulfill specific requirements of the SIMREF? If so, which ones?
2. Using a thin client (non-server based) object based delivery mechanism, is it possible to fulfill the requirements of the SIMREF using SCORM 2004 without any extensions?

3. If extensions other than SCO to SCO data sharing are needed for SCORM 2004 to fulfill the requirements of the SIMREF what would they be?
4. Using a standard browser-based delivery mechanism, is SCORM 2004 sequencing adequate for fulfilling all of the requirements of the SIMREF? If not, what sequencing specific extensions are required?
5. Using a standard browser-based delivery mechanism, is complex arbitrary data sharing between SCOs necessary to fulfill specific requirements of the SIMREF?
6. Is it necessary to use customized LMS functionality and communications to fulfill specific requirements of the SIMREF?
7. As gaps are identified in fulfilling the requirements of the SIMREF, do relationships exist between them?

Survey Methodology as a Total Survey Design

When using a survey as the primary form of data collection, the survey design and survey sampling procedures are critical. According to Fowler (2002), survey validity depends on its total design and on the treatment of the design's critical components: sampling, question design, interviewing, and mode of data collection (Fowler, 2002). Hutchinson (2004) discusses these same components as the stages in conducting a survey. She lists them as Stage 1: Preliminary Planning, Stage 2: Selecting the Respondents, Stage 3: Survey Construction, Stage 4: Survey Dissemination, and Stage 5: Survey Analysis. Each component or stage has critical design considerations that demand decisions affecting the total survey design and its validity. The following sections will discuss these components and their decision points in respect to the scope of this study.

Sampling

A sample refers to a subset of the total population under study and a population is the total number of cases possible (Robson, 2002). Sampling is the process of obtaining a manageable subset of cases or responses that are representative of the population. As a critical component of a total survey design, sampling strategies and procedures are of paramount importance. They determine how representative of the total population the sample is and affects external validity or generalizability.

When planning and designing a sampling strategy there are critical issues and decision points that should be considered. Hutchinson (2004) describes decisions needed about how and by whom the results will be used as preliminary planning to the actual sampling. Also, she states that decisions have to be made concerning who the respondents will be, how they will be selected, and how many are needed (sample size). Fowler (2002) discusses several decision points that occur when determining the sampling strategy and its resulting procedures. After the target population description, these points represent the framework the researcher used to discuss the sample and its validity and include the choice of whether or not to use a probability sample (sample type), the sample frame, the sample size, the sample design, and the response rate.

In this study, the target population or the group to whom the results are generalized (Mertens, 1998), consists of all individuals with experience implementing SCORM-based online web-based learning or training (WBT) solutions. Members include those that are active in their respective fields such as instructional technologists, instructional designers, or IT (information technology) developers that develop or implement WBT and develop or implement WBT that is considered SCORM 2004 conformant. Geographically, members could be located world-wide and may work virtually at home or as part of a virtual team or at a designated brick and mortar facility. They can be considered knowledge workers and rely heavily on ICT (information and communication technology) as users, developers, or both. Individual education levels could range from a high school diploma or equivalent to undergraduate and graduate degrees majoring in education, computer science, information technology, instructional design, instructional technology, electrical engineering, or information systems management. Members of the population are employed by technology companies (e. g. LMS vendors), government contractors, and government service employees for worldwide governmental or government sponsored agencies (e.g. K.E.R.I.S.).

From within the target population the experimentally accessible population contains consisted of members of the ADL Technical Working Group (TWG) or attendees to ADL's Implementation Fest 2007 at the Rosen Center Hotel in Orlando, Florida August 27-30, 2007 (http://www.jointadlcolab.org/newsandevents/ifests/2007/briefs.aspx). Within the experimentally accessible population, a sample frame was constructed consisting of members of the ADL TWG and those who chose to complete a survey at a booth available during Implementation Fest 2007.

Sampling design consisted of an oversampling approach using two different modes and was developed through self selection, snowball, and comprehensive techniques. This approach supported greater generalization then what normally may be the case in developmental and evaluative research using techniques such as purposeful sampling. Self selection may not generalize well to the target population due to the potential for not being representative (Andrews, Nonnecke, & Preece, 2003; Hutchinson, 2004) introducing bias into the sample. Oversampling and a more comprehensive sampling approach, however, can allow for robust statistical analysis and facilitate generalizability to the target population (Fowler, 2002; Hutchinson, 2004; Mertens, 1998).

The sample pulled from the overall target population came from two sources: all members of the TWG or their representatives contacted by ADL and attendees to ADL's Implementation Fest 2007. Both sources used a snowball approach to increase participation facilitating oversampling. All members of the sample frame were either contacted by ADL through email facilitating the comprehensiveness of the sample frame or they were self-selected during the Implementation Fest 2007. All participants were asked to let others know that participants were being sought.

According to Robson larger sample sizes lend themselves to greater confidence in generalizing to the population (Robson, 2002). Hutchinson considers selecting all members of a population as a comprehensive sample and thus generalizable to that population (Hutchinson, 2004). Fowler differentiates between minimum sample sizes based upon representiveness and confidence and lists three common misconceptions on basing sample sizes: basing sample size solely on a fractional number of the population, basing sample size solely on prior research using similar populations, and basing it solely on predefined need for precision. He further states that it is a combination of the above and each sample is unique in its own needs (Fowler, 2002). Also Mertens (1998) notes that in correlational research a recommended number of participants per variable is 15 (Robson, 2002).

The size of the population of those developing and implementing e-learning solutions overall is not large and the subpopulation of those specifically implementing SCORM is even smaller and is somewhat more specialized. For example, there are 648 registered users on adlcommunity.net an online community of practice dedicated to those interested in SCORM and other ADL programs (adlCommunity, 2007b). There are approximately 200 organizations recognized as SCORM adopters by ADL (ADLNet, 2006) and 77 points of contact (POCs) in the ADL Technology Working Group (TWG) ADL's advisory committee and a subset of the SCORM adopters (ADL, personal communication, June 22, 2007). Also, the number of attendees to the 2006 Implementation Fest totaled 350 with those having titles indicating organizational roles of a developer nature numbering between 200 and 230. The number of attendees to the 2007 Implementation Fest totaled 331 (no role data available to date).

Using these lists as a guide, these indicators may define the population size of those working for a recognized SCORM adopter organization from 200 to 2000 assuming a minimum of one per organization and a maximum of 10 per organization. The reality is that the size most likely lies somewhere in between. This is indicated by the user base of adlcommunity.net and the attendees to Implementation Fest 2006-2007. The number of those with likely developer roles from Implementation Fest 2006 indicates that the population size may be closer to the lower number of 200.

For the purposes of this study, a moderate approach to describing the population size is to assume a size of 250 with a target sample size of ≥ 25 or 10% of the population. This meets Fowler's (2002) criteria of a combination of factors determining sample size. In this case the combination consisted of a target percentage of 10% and prior role research of past attendees from the Joint ADL Co-lab (personal communication, July 18, 2007). This combination would also give a potential minimum number of participants per variable of 25.

Response Rates

Using online methods of survey dissemination and data collection require specific techniques to help ensure that surveys are submitted (returned). Andrews et al (2003) recommend using a combination of methods when possible including email and web-based forms in combination with postal surveys. Also, the instrument design itself can affect completion and an email solicitation should not include the survey itself with the email. It should either be sent in another email or included as a link outside the cover letter.

Usually in email surveys or purely web-based ones, respondents will need at least two follow-up contacts to ensure completion (Andrews et al., 2003). Also, a significant pitfall with email solicitation is the growing number of unsolicited emails increasing the potential that the emailed survey will never reach its intended recipient due to spam filters and firewalls.

There are multiple types of responders to web-based forms each exhibiting unique characteristics to be taken into account. Bosnjak & Tuten in Andrews et al, identified several categories of response types to web-based surveys that include: complete responders, unit responders (do not participate at all), answering drop outs, lurkers, lurking drop outs, item non-responders (answers some of the questions but completes the survey), and item non-responding drop-outs (answers some questions, but drop out before completing).

Data Collection

This section is organized first by the instrument development and question design. This is followed by the variables and hypotheses including a map of the relationships of the hypotheses, survey items, variables, and analysis method. Next is the mode of data collection and the procedures followed including the overall timeline. This is followed by the organization of the data.

Instrument Development and Question Design

Instrument development began with the development of a set of real-world requirements derived from a simulation existing as a primary component of an online learning environment and exhibiting specific characteristics as defined in Maier and Grobler's taxonomy (Maier & Grobler, 2000). For this task PharmaSim (described in-depth in Chapter 2) combined with requirements analysis techniques from the software engineering field was used to extract and develop a baseline set of requirements.

These baseline requirements represent those requirements necessary to field an online simulation delivered as a complete SCORM 2004 content package. As such, the extracted requirement set represents an analysis of the functional areas and user/system interactions necessary for the functionality of an online simulation in the context of an online course or learning environment launched and tracked by a LMS. The various functional areas of the simulation as well as those surrounding the entire learning environment were first diagramed as a use-case level diagram describing what functions were considered sea (user) level, what were summary level, as well as those at sub-sea level. The diagram representing the use-case scope of PharmaSim from which the requirements and sub-requirements were derived can be found in Appendix A.

Next, to target the specific areas of SCORM under scrutiny (i.e. RTE and Sequencing), these requirements were tailored. Tailoring occurred through formative sessions with two leading SCORM developers from both ADL and industry respectively. First, the requirements were adjusted or slightly modified to maintain the following overarching tenets: maximum reuse across multiple environments, interoperability, and durability. Next, to ensure that the requirements would target the necessary scope, a set of developmental parameters were developed. These parameters were included as part of the final survey and were intended to guide the thinking of the survey respondents as they completed the survey and included the following: 1) Development will use multiple SCOs not a single large SCO; 2) development should use SCOs that are based upon functionality or type instead of just instructional content (A functional SCO is a SCO that provides a specific function or set of functions not necessarily intended to deliver conventional instructional content - i.e. a role assignment function or a scenario choice function.); 3) all functional SCOs will be delivered as components of the course content package; 4) SCOs should be considered to have specific functionality so that the set of SCOs making up the content package will work together as a system; 5) a simulation engine will be embedded within a SCO and delivered as part of the course content package; 6) SCOs will not be required to communicate with an external system; and 7) network accessibility is not a factor.

The requirements were then trimmed and adjusted once again to tailor the assessment to requirements coupling with the run-time environment, sequencing functionality of SCORM 2004, and SCO implementation. This final set of functional requirements was documented into a simulations requirements framework or SIMREF

(Appendix B). In terms of a gap analysis, the SIMREF represents the criterion or a desired state and was transformed into explanatory variables to facilitate data collection and analysis.

In order to address the research questions, a 50 item survey was developed called the Sim SCORM 2004 Survey (Appendix C). Based on the research questions, six indicators (survey items) and two open-ended questions were constructed. The indicators, in the form of agreement statements, were based upon the relevance of the indicator to each requirement as perceived by each respondent. In total, six agreement statements were constructed eliciting relevance levels as items on a traditional five point Likert scale (Maurer & Andrews, 2000) with a rating of 1 equaling strongly disagree and a rating of 5 equaling strongly agree. The final form of the survey used the six Likert items matrixed against each of the eight requirements of the SIMREF resulting in a total of 48 Likert items plus two open-ended questions not tied to a specific requirement.

To address research question one, two indicators were developed measuring the relevance of a SCO to fulfilling each requirement and the relevance of a functional or typed SCO to fulfilling each requirement. As using one of more SCOs is inherent to SCORM development, assessing the perception of SCO relevancy to the requirements also helps to understand the experience level and thinking of the respondent and, as such, help to baseline the other responses. To address question two, an indicator was developed measuring the relevance of extending or modifying SCORM 2004 other than SCO to SCO data sharing. As the addition of SCO to SCO data sharing would be considered an extension to SCORM 2004 and is potentially a necessary extension to fulfilling the SIMREF, these were treated separately. Question three was addressed using two overall open-ended questions asking the respondent to list any other standards or specifications other than SCORM 2004 currently existing that could meet the SIMREF or, if none existed, to describe ones that would need to be developed. Addressing question four required an indicator measuring the relevance of modifying SCORM sequencing to fulfilling the requirements. It also was addressed through the two open-ended questions targeting question three. Question five was specifically addressed by an indicator measuring the perceived relevance of SCO to SCO data access or data sharing between SCOs to fulfilling the requirements. Lastly, question six was addressed using an indicator assessing the perceived relevance of using a LMS provided thick client with communication to external systems and specific LMS functionality to fulfilling the requirements.

As in the tailoring of the requirements of the SIMREF, validity of the assessment indicators was ensured through formative development sessions using feedback from two leading SCORM developers from both ADL and from industry repsectively. This occurred over several cycles through personal conversation, interviews, emails, and telephone calls. Also, as survey form is crucial to response rates and response accuracy, it was also developed formatively with usability feedback from a pool of 5 IT developers and instructional systems designers employed with a primary defense contractor located in Northern Virginia.

The final form of the survey consisted of an introduction section explaining the study, the purpose and scope of the survey, and instructions for completion. Next was a demographic section collecting demographic data detailing how the respondent's education and experience levels with information technology, instructional systems design, SCORM and non-SCORM course development, LMS integration, and enterprise e-learning solution development. Demographic data collection was intentionally included at the beginning of the survey to help increase response rates (Andrews et al., 2003). Following the demographics was the section containing the eight requirements with six response items each. Finally, to conclude the survey were the two open-ended questions.

Explanatory and Outcome Variables

In cross-sectional studies of fixed non-experimental design, variables are referred to as explanatory and outcome variables respectively (Mertens, 1998; Robson, 2002) and may or may not be associated with a statistical procedure. The explanatory variables in this study were derived from the SIMREF and consisted of eight requirements each with a main requirement and sub-requirements. Table 1 (below) lists the main requirements and their assigned variable names and the complete set of main and sub-requirements are found in the SIMREF in Appendix B. It was assumed that to fulfill a main requirement all of its sub-requirements must be fulfilled.

Table 1

SIMREF Requirements and Explanatory Variables

Main requirement	Explanatory variable
User selects role and chooses a scenario within the simulation-based course	REQ1
User views case (scenario overview) and is welcomed to the course	REQ2
Data flows as input and output from an embedded	REQ3

Main requirement	Explanatory variable
simulation	
User views available reports contextual to the scenario and simulation progression	REQ4
Budget feedback system will be provided	REQ5
User views status	REQ6
Coaching system is available upon request	REQ7
User provides end of period reflection	REQ8

A set of outcome variables was developed to analyze and answer those research questions obtaining quantitative data. The outcome variables were mapped with and designed to answer the research questions requiring a yes or no type of answer. The variables were also developed to map to each survey item (indicator) at the individual requirement and overall level of the SIMREF as required. The relationship of quantitative research question to outcome variables is found in the map presented in Figure 9. The following outcome variables and measure descriptions used and are listed in the following table (Table 2).

Table 2

Outcome Variable and Measures

Outcome variable	Measure
SCO_REQ	SCOs relevance to fulfilling a requirement

Outcome variable	Measure
FUNCTSCO	Functional scos relevance to fulfilling a requirement
SCORMSEQ	Relevance of modifying SCORM's sequencing to fulfilling a requirement
SCO2SCO	Relevance of SCO to SCO data access or data sharing between scos to fulfilling a requirement
SCORMEXT	Relevance of extending or modifying SCORM other than SCO to SCO data sharing to fulfilling a requirement
LMSCLIENT	Relevance of using a LMS provided thick client with communication to external systems and specific LMS functionality to fulfilling a requirement
FS_S2S	Correlation coefficient of FUNCTSCO and SCO2SCO
FS_SEQ	Correlation coefficient of FUNCTSCO and SCORMSEQ
FS_EXT	Correlation coefficient of FUNCTSCO and SCORMEXT
S2S_SEQ	Correlation coefficient of SCO2SCO and SCORMSEQ
S2S_EXT	Correlation coefficient of SCO2SCO and SCORMEXT

As question three is more qualitative in nature, it is not included in the map in Figure 9. For question three, quantitative data gathered on the outcome variables provide an indicator of the necessity of extensions to SCORM as the qualitative data collected is analyzed. Qualitative data gathered through the open-ended survey questions were then analyzed thematically to answer this research question. The analysis looked for standards and technologies either existing or to be developed that might be good candidates for necessary extensions to SCORM 2004 in fielding the requirements presented in the SIMREF.

Mode of Data Collection and Procedures

The modes of data collection consisted of a web link deployed through email, using stand alone computers, and as a paper-based survey. First, the survey was created as a Microsoft Word document and multiple copies made and numbered. Next, the survey was created as an online web-based survey using QuestionPro online survey software (http://www.questionpro.com). Finally, the survey was created as a database application using the forms tool in Groove (http://www.groove.net). Groove is a peer to peer collaborative application allowing both stand-alone and network operations.

The total data collection period consisted of three months beginning June 1, 2007 and ending August 31, 2007. Initial deployment of the survey used a web link to the survey URL (https://www.questionpro.com/akira/TakeSurvey?id=713973). The URL was sent in a cover letter (email) to the members of the ADL TWG asking for their participation. The cover letter introduced the research and the researcher, asked for participation in the research, and included its endorsement by ADL. This cover letter is reproduced in Appendix D.

Lastly, numbered paper copies and the Groove Forms version (using two lap-top computers) of the survey were available at a booth at Implementation Fest 2007. Respondents were solicited during the exhibition sessions from the total attendees to the Implementation Fest. This had the advantage of exposure to the total number of attendees as meals and refreshments (included with registration) were served in the exhibit hall. A screen capture of the online version of the survey can be found in Appendix E and the Groove version of the survey can be found in Appendix F.

Timeline of the Study

The overall timeline of the study was as follows (in months):

Instrument development:	May 2006-May 2007
Data Collection:	June-August 2007
Analysis	September 2007
Results and Conclusions	September-October 2007

Organization of the Data

Data gathered were primarily quantitative and consisted of interval data with values ranging from one to five. Also, gathered were qualitative data through the two open-ended questions in the survey. Quantitative data were collected and analyzed at both the individual requirement and the requirement set levels of the SIMREF. All data were left in their interval form with no specific coding taking place. Analysis procedures (detailed in Chapter 4) included descriptive statistical analysis to look for sample normalcy and define the characteristics of the data. Also, performed were means comparisons and Boolean comparisons of the mean values to answer yes or no questions. Finally, Chi-Square Tests and linear regression were performed to look for correlations between specific outcome variables. For a comprehensive view of the relationships of hypotheses, variables, and analysis procedures a mapping of hypotheses, survey items, variables, and analysis procedures was produced. This map can be found in Map of Quantitative Research Questions, Survey Items, Variables, and Analysis Method (Figure 9).

Validity

Validity is concerned with findings actually being about what they appear to be about. This is characterized as trustworthiness or, in other words, are the findings true or representative of the population (Robson, 1993)? Validity issues can occur as a result of the overall research design and the data collection methods employed. Different research genres and designs have different inherent validity threats. These threats are inherent in the sample makeup and procedures used, the accuracy and consistency of the data collection instrument(s), and how the data were analyzed. In analysis, validity threats also occur through the existence of other plausible alternative explanations (Maxwell, 1996).

In a fixed research design, the above validity threats are included in what is called the design's internal validity and include specifically history, testing, instrumentation, regression, mortality, maturation, selection, and selection by maturation interaction (Robson, 2002). Typically, internal validity is referred to in terms of the accuracy of the measures and the consistency of the measurements taken. The latter is referred to as the reliability. In correlational cross-sectional studies employing survey methods, threats to internal validity mostly exist as construct validity, reliability, and sampling strategy.

Construct validity is construed as the accuracy of measurement by the chosen instrument or "does it measure what it is supposed to measure?" Construct validity threats were mitigated by the use of subject matter experts in the formative process of developing the SIMREF which evolved into the assumptions of the Sim SCORM 2004 Survey and explanatory variables of the study. Also, subject matter experts were used in a formative process of developing the indicators or survey items that evolved into the outcome variables.

Reliability is the consistency of the measure taken and can be referred to as having stability and/or internal consistency. Stability refers to the consistency of a measure that is taken and repeated over time (Jaeger, 1993). For example, if something's length is measured to be 12 inches by a ruler, every time it is measured by the same ruler it is read as being 12 inches long. For a single measure the term for consistency is internal consistency. Although there are a several recognized methods that assess internal consistency including Cronbach's alpha, however there were no consistency assessments performed on the final form of the data collection instrument.

External validity is also of concern. External validity or generalizability is the ability of the findings to be applied outside the sample population. General threats to external validity in fixed research designs include selection, setting, history, and construct effects. In correlational cross-sectional studies, a primary concern is the sampling strategy and the homogeneity of the group being sampled (Mertens, 1998; Robson, 2002). Besides homogeneity, other characteristics of the sample are very important to achieving external validity or generalizability. These characteristics exist in the description and methods of selecting the sample frame and the sample size. Also important are the sampling design and the response rates (Fowler, 2002).

Sampling strategy as a concern to external validity was mitigated in the design of the sample frame, sampling methods, and sample size. This study mitigated the risk of low response rates by oversampling of the sample frame and using multiple modalities and survey delivery methods. This was also mitigated by the construction of the survey instrument and placement of the demographics to survey items.

Internal and external validity tend to have an inverse relationship as the various controls that need to be applied to boost internal validity tend to contextualize the findings to the sample thereby reducing generalizability (Robson, 2002). This study was concerned most with external validity or generalizing findings to the target population and was limited in the absence of reliability measurements of the data collection instrument. The next chapter will present the findings of the analysis.

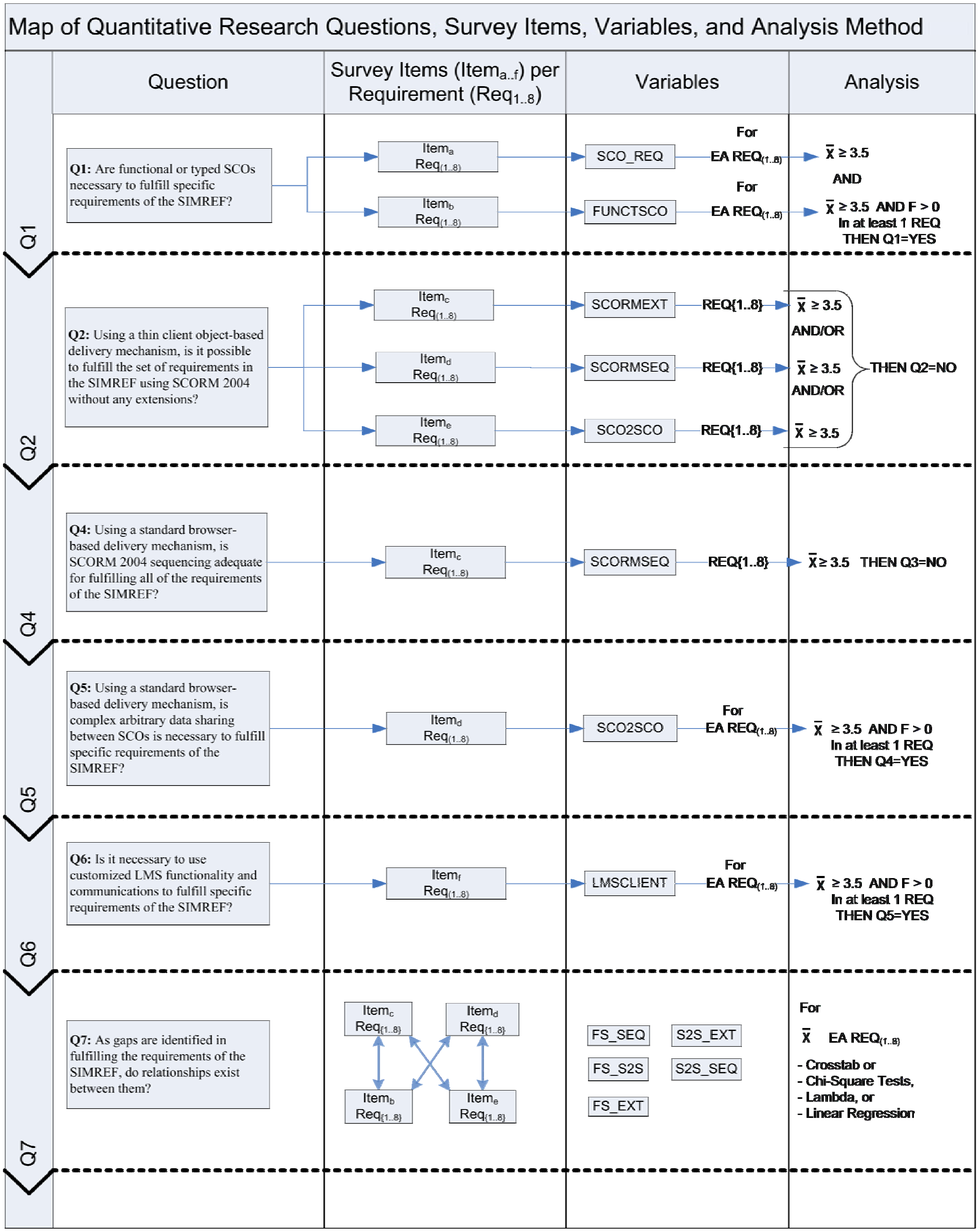


Figure 9. Map of Questions, Items, Variables, and Analysis.

4. Presentation of Findings

Presentation of the Data

This study employed primarily a descriptive approach to answering the research questions.. All quantitative data were analyzed using two commercially available tools: a statistical analysis package and an electronic spreadsheet. All qualitative data were analyzed using a common word processor. This chapter presents the quantitative data by research question. It then presents the qualitative data by open-ended survey item. The organization of this chapter begins with an analysis of the demographic data describing the characteristics of the sample frame. Following the demographics, the findings are presented by research question then by open-ended survey item.

Demographics

Demographic descriptions are important in understanding the characteristics and representativeness of the sample and are therefore presented here in their entirety. The sample consisted of 26 respondents to the Sim SCORM 2004 Survey. The demographics of the participants making up the sample consisted of the following categories: *Employer Type*, *Highest Degree,* and *Years of Experience*.

For Employer Type, the choices consisted of *Academic, Government, Industry- Content Developer, Industry- Government Contractor, Industry- LMS Developer, and Standards/Specification Entity*. Participants were allowed to choose all types appropriate resulting in the possibility of primary, secondary, and tertiary employment types per response. Employer Type had an open ended item allowing other types to be input. Also, an open ended item was provided for describing the specific government agency if the participant chose *Government* as the Employer Type.

For Highest Degree, the choices were *High School Diploma, Associates Degree, BA or BS, MA or MS, PhD*, and *Other* (open ended). Also, an open ended item was also included for describing the degree area if appropriate. Years of Experience was divided into experience with IT (information technology), ISD (instructional systems design), developing SCORM 1.x conformant courseware, developing SCORM 2004 conformant courseware, developing non-SCORM courseware, integrating courseware with a learning management system (LMS), and designing enterprise level e-learning solutions. The categories for each experience area except SCORM 2004 were *No Experience*, *Less than 1 Year*, *1 to 3 Years*, *4 to 7 Years*, *8 to 10 Years*, and *Over 10 Years*. As SCORM 2004 was only released in 2004, the SCORM 2004 experience levels were *No Experience*, *Less than 1 Year*, and *1 to 3 Years*.

Primary, secondary, tertiary, combined (all three) categories of Employer Type were analyzed and the data presented. As the secondary and tertiary categories were small, the prominent categories discussed are Primary Employment and Combined Employment. In analyzing Employer Type, it was determined that 65% listed some type of industry as their primary employer type. Out of those the majority was Industry - Content Developer (35%) followed next by Industry - Government Contractor (19%) then by Industry - LMS Developer (12%). The next largest category was listed as Government (19%) followed by Standards/Specifications Entities (8%) and lastly by Academic (4%). For those indicating government agencies, open ended items listed agency types as the Department of Defense (DoD), the Defense Equal Opportunity Management Institute (DEOMI), and the Navy.

The analysis of all three categories of Employer Type as the Combined Employer Type may gives a comprehensive picture of the weighting of the organizations represented. This profile varied somewhat with the primary employer type with Industry - Government Contractor leading with 29%, followed by Industry - Content Developer with 26%. Government agencies and Standards/Specifications Entities were evenly represented with 16% followed by Industry - LMS Developer (8%) and Academic (5%). These data are presented in the following tables and pie charts with any missing response labeled as *Missing*. Large values for Missing occur in Secondary Employment and Tertiary Employment due to fewer participants responding with more than one response for Employee Type.

Table 3

Primary Employment

Employment Area	Frequency	Percent	Valid percent	Cumulative percent
Missing	1	3.8	3.8	3.8
Academic	1	3.8	3.8	7.7
Government	5	19.2	19.2	26.9
Industry content dev	9	34.6	34.6	61.5
Industry gov contractor	5	19.2	19.2	80.8
Industry LMS dev	3	11.5	11.5	92.3
Standards/specification entity	2	7.7	7.7	100.0

Table 4

Secondary Employment

Employment Area	Frequency	Percent	Valid Percent	Cumulative Percent
Missing	17	65.4	65.4	65.4
Academic	1	3.8	3.8	69.2
Government	1	3.8	3.8	73.1
Industry content dev	1	3.8	3.8	76.9
Industry gov contractor	5	19.2	19.2	96.2
Industry LMS dev	1	3.8	3.8	100.0
Total	26	100.0	100.0	

Table 5

Tertiary Employment

Employment Area	Frequency	Percent	Valid Percent	Cumulative Percent
Missing	22	84.6	84.6	84.6
Industry gov contractor	1	3.8	3.8	88.5
Standards/specification entity	3	11.5	11.5	100.0

Table 6

Combined Employer Type

Employee Type	Frequency	Percent	Valid Percent	Cumulative Percent
Academic	2	5.3	5.3	5.3
Government	6	15.8	15.8	21.1
Industry content dev	10	26.3	26.3	47.4
Industry gov contractor	11	28.9	28.9	76.3
Industry LMS dev	3	7.9	7.9	84.2
Standards/specification entity	6	15.8	15.8	100.0
Total	38	100.0	100.0	

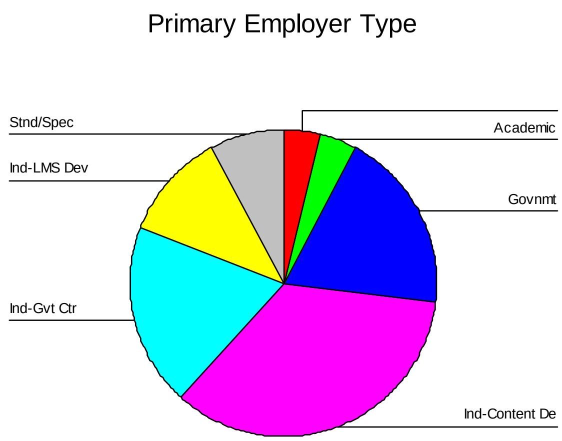


Figure 10. Demographic 1

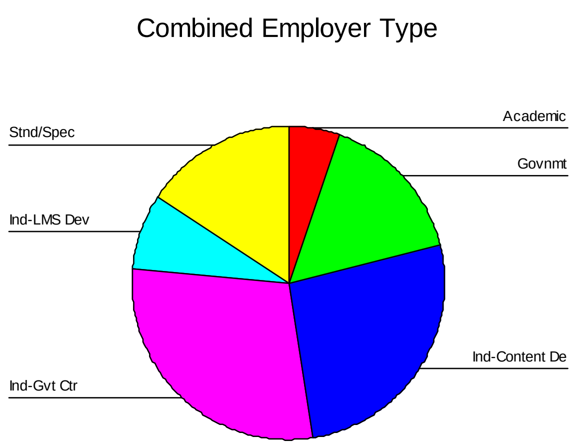


Figure 11. Demographic 2

For Highest Degree, 46% indicated a highest degree attained as either a MA or MS. This was followed 35% indicating either a BA or BS and 12% indicating a PhD as the highest degree attained. There were 4% indicating *Other* and 4% that did not respond to this category. There were no open ended responses for Other descriptions and three open ended responses for degree area: Computer Science, Political Science, and Cognitive Science. These findings are illustrated in the following pie chart.

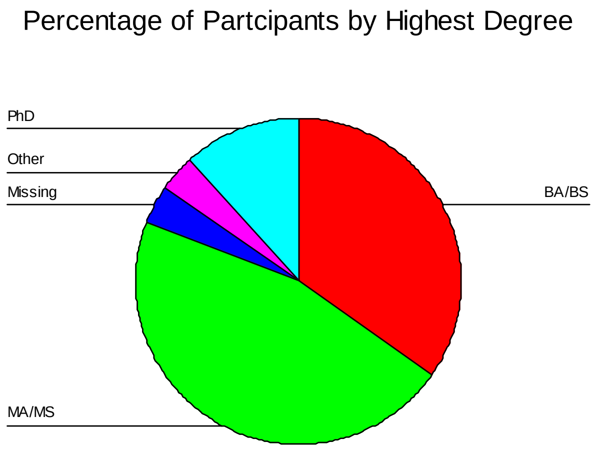


Figure 12. Demographic 3

In analyzing the experience levels of the sample, 69% had some experience in IT and 65% had some experience in ISD. Out of these categories 35% and 23% overall had listed over 10 years of experience in IT and ISD respectively. Those with some experience developing SCORM conformant courseware were 69% for SCORM 1.1 or 1.2 and 69% for SCORM 2004. Of those with SCORM 1.1 or 1.2 experience 23% had over 8 years experience with 38% with between 1 and 7 years experience. Of those developing non-SCORM conformant courseware, 88% had 1 or more years experience with the largest percentage (54%) claiming over 10 years experience. 88% of respondents claimed experience integrating courseware with LMSs and 46% claimed some experience designing enterprise e-learning solutions. These data are presented in the following tables and pie charts.

Table 7

IT Experience

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	2	7.7	7.7	7.7
4 to 7 Years	1	3.8	3.8	11.5
8 to 10 Years	5	19.2	19.2	30.8
Less than 1 Year	1	3.8	3.8	34.6
Missing	1	3.8	3.8	38.5
No experience	7	26.9	26.9	65.4
Over 10 years	9	34.6	34.6	100.0

Table 8

ISD Experience

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	4	15.4	15.4	15.4
4 to 7 Years	3	11.5	11.5	26.9
8 to 10 Years	4	15.4	15.4	42.3
No experience	9	34.6	34.6	76.9
Over 10 years	6	23.1	23.1	100.0

Table 9

Experience SCORM 1.2

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	4	15.4	15.4	15.4
4 to 7 Years	6	23.1	23.1	38.5
8 to 10 Years	5	19.2	19.2	57.7
Less than 1 Year	2	7.7	7.7	65.4
No experience	8	30.8	30.8	96.2
Over 10 years	1	3.8	3.8	100.0

Table 10

SCORM 2004 Experience

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	13	50.0	50.0	50.0
Less than 1 Year	5	19.2	19.2	69.2
No Experience	8	30.8	30.8	100.0
Total	26	100.0	100.0	

Table 11

Non-SCORM Experience

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	3	11.5	11.5	11.5
4 to 7 Years	4	15.4	15.4	26.9
8 to 10 Years	2	7.7	7.7	34.6
No Experience	3	11.5	11.5	46.2
Over 10 Years	14	53.8	53.8	100.0

Table 12

Experience Integrating with LMS

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	9	34.6	34.6	34.6
4 to 7 Years	4	15.4	15.4	50.0
8 to 10 Years	5	19.2	19.2	69.2
Less than 1 Year	2	7.7	7.7	76.9
No Experience	3	11.5	11.5	88.5
Over 10 Years	3	11.5	11.5	100.0

Table 13

Enterprise Learning Experience

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 3 Years	3	11.5	11.5	11.5
4 to 7 Years	2	7.7	7.7	19.2
8 to 10 Years	3	11.5	11.5	30.8
Missing	12	46.2	46.2	76.9
No Experience	2	7.7	7.7	84.6
Over 10 Years	4	15.4	15.4	100.0

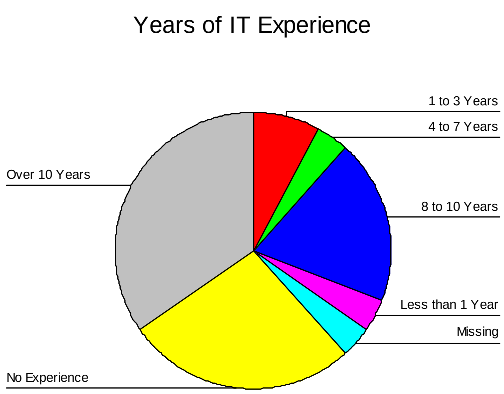


Figure 13. Demographic 4

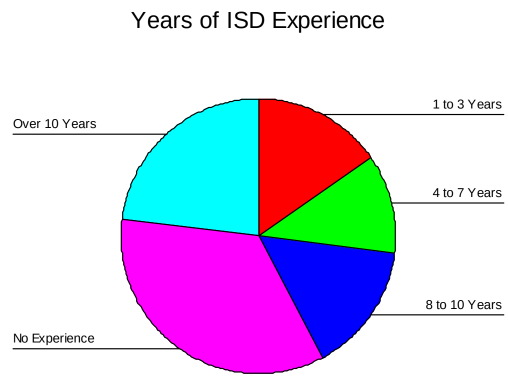


Figure 14. Demographic 5

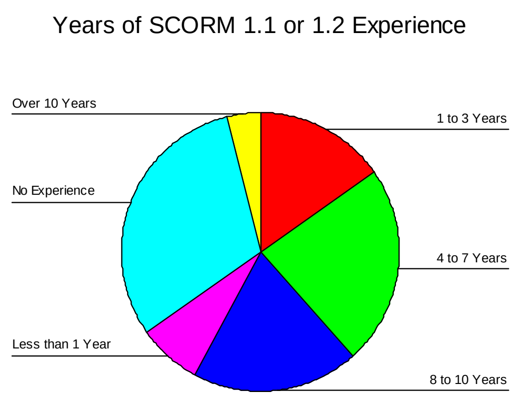


Figure 15. Demographic 6

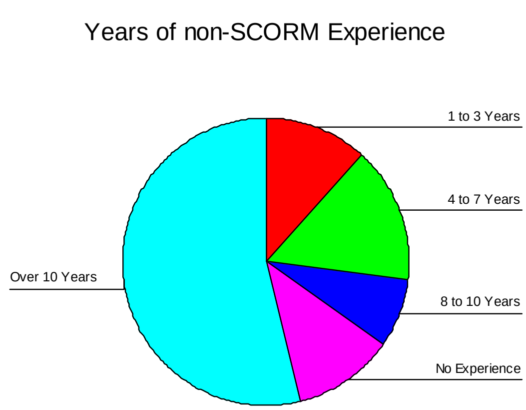


Figure 16. Demographic 7

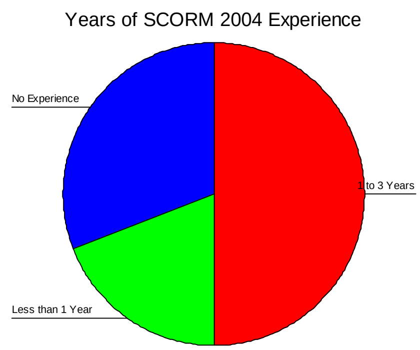


Figure 17. Demographic 8

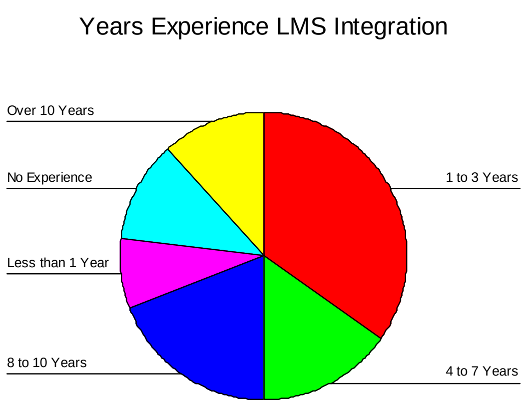


Figure 18. Demographic 9

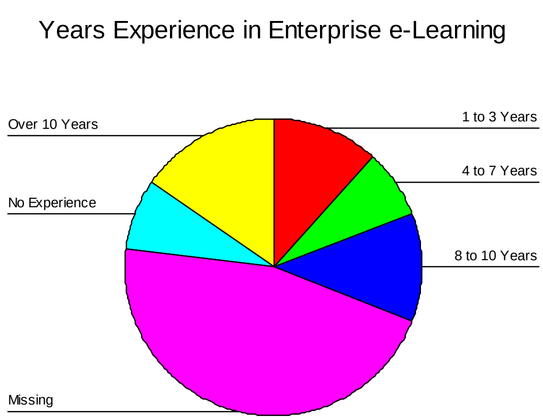


Figure 19. Demographic 10

Demographics Summary

In summary, most of the participants are employed in industry as content developers or government contractors. There are also a significant number of participants employed by the government, standards/specifications entities, or LMS developers. The least representation came from academics. Participants are all well educated with the majority having attained either a BA/BA degree or MA/MS degree. Most participants are very experience in informational technology or instructional systems design and have been developing courseware of some kind for over 10 years. There was also a high degree of SCORM experience especially SCORM 2004 (50%). Demographically, this sample represents highly experience, well educated developers from industry, government, standards/specifications entities, and academics.

Findings by Research Question

This section presents the findings of the study organized by research question. As stated in the previous chapter, to answer the research questions requiring a yes or no answer, descriptive procedures were required. Depending on the nature of the question, analysis was performed at either the individual requirement level or the SIMREF (requirement set) level. For Questions 1, 4, and 5, the unit of analysis was at the requirement level. The nomenclature for a requirement level variable is the variable name followed by a number one through eight. For example, SCO_REQ at the requirement level would be labeled SCO_REQ1. SCO_REQ1 would then contain the values of SCO_REQ for the first requirement of the SIMREF only. For greater clarity for table presentation, values (i.e. means) of these requirement level variables (i.e. SCO_REQ1) are found in the cells with the row labeled with the SIMREF level variable (i.e. SCO_REQ (1-8)) and columns labeled with the requirement number (i.e. Req1).

This study used a five point Likert scale of agreement to statements of relevance. For analysis, this scale is used in the following way: values of 1 represented no relevance, values of 2 represented little relevance, values of 3 represented values of neutral relevance, values of 4 represented some relevance, and values of 5 represented high relevance. As variable means were produced, they were then looked at in terms of three categories: ≤ 2.49 equals negative relevance, 2.50 - 3.49 equals neutral relevance, and ≥ 3.50 equals positive relevance. As the data were analyzed there were little neutral values produced, therefore recoding into these categories was not necessary for further analysis.

For research questions requiring answer for “which ones” or “what types,” both quantitative analysis and qualitative analysis were used. Quantitative analysis pointed to which variable met specific conditions and qualitative analysis was employed to understand more about the condition. Qualitative data collected through open-ended items 1 and 2 were also analyzed thematically, comparatively, and contextually with the data presented in multiple formats including lists, tables, and quotes.

Research Question 1

In answering the question “Are functional or typed SCOs necessary to fulfill specific requirements of the SIMREF and if so, which ones?” required a comparative analysis of the means of the requirement level variables FUNCTSCO (1-8) to determine which of the requirements had a $\bar{X} \geq 3.50$.

First, a set of descriptive statistics with histograms of the requirement level variables SCO_REQ (1-8) (i.e. SCO_REQ by Req1-8) and FUNCTSCO (1-8) (i.e.

FUNCTSCO (1-8) by Req1-8) were produced. Important outcomes from these statistics were the mean, frequencies, standard deviations, and range values.

After producing the descriptive statistics, the means were examined for the condition of $\bar{X} \geq 3.50$ in all variables. If the condition was true for at least one variable, then the answer is yes. In addition, frequencies, standard deviation, and range of both variables were examined for normalcy and dichotomy in the results.

From the data presented, each variable pair has a mean of > 3.50 thereby giving a positive answer. As there are no direct comparisons of means, the standard deviation is provided for insight into the variance in the values of each variable.

For SCO_REQ (1-8), standard deviation values range from 1 to 1.3 per requirement mean indicating a marginally wide degree of variance across a 5 point scale. However, the range values are 4 on SCO_REQs (1-7) and 3 on SCO_REQ8. This may indicate that there are no large dichotomies in the data.

For FUNCTSCO (1-8), standard deviation values range from .9 to 1.4 per requirement mean again indicating a marginally wide degree of variance. However, the range values across all requirements are 4. This may again indicate that there are no large dichotomies in the data.

To answer the question of which requirement of the SIMREF requires a functional or typed SCO, the means of FUNCTSCO (1-8) were analyzed for the condition of $\bar{X} \geq 3.50$. As there were no values below 3.5, this indicates that all eight requirements of the SIMREF require a functional or typed SCO to fulfill.

Table 14 and Figure 20 present the variable means by variable and requirement. The descriptive statistics of SCO_REQ (1-8) and FUNTSCO (1-8) are presented in the Tables 15 and 16.

Table 14

Mean of Variables by Requirement

Variable	Req1	Req2	Req3	Req4	Req5	Req6	Req7	Req8
$\bar{X}$ SCO_REQ(1-8)	4.00	4.08	3.52	3.60	3.36	3.56	3.96	3.60
$\bar{X}$ FUNCTSCO(1-8)	3.88	3.64	3.67	3.68	3.68	4.12	4.00	3.52

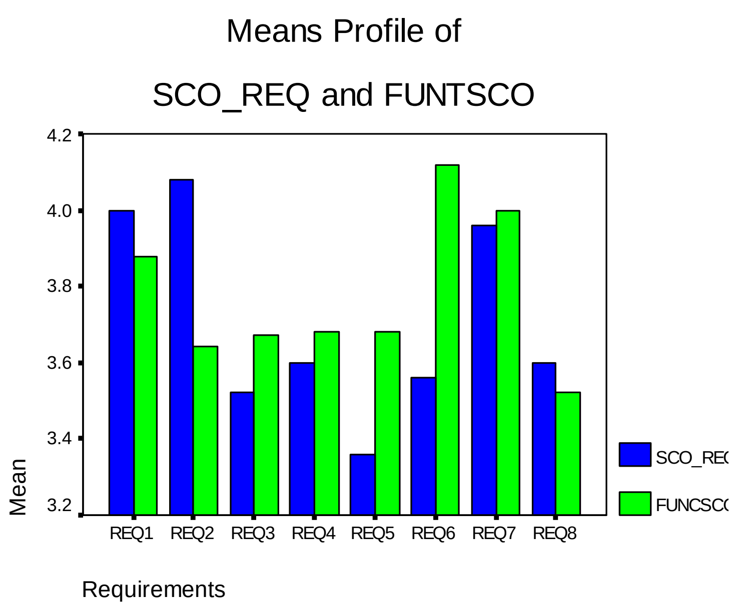


Figure 20. Research Question 1 Means

Table 15

SCO_REQ (1-8) Statistics

Statistic	Req1	Req2	Req3	Req4	Req5	Req6	Req7	Req8
Mean	4.00	4.08	3.52	3.6000	3.36	3.56	3.96	3.60
Std. deviation	1.23	1.08	1.31	1.32	1.25	1.16	1.10	1.00
Variance	1.52	1.16	1.72	1.75	1.57	1.34	1.21	1.00
Range	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.00
Minimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 16

FUNCTSCO (1-8) Statistics

Statistic	Req1	Req2	Req3	Req4	Req5	Req6	Req7	Req8
Mean	3.88	3.64	3.67	3.68	3.68	4.12	4.00	3.52
Std. deviation	1.21	1.15	1.37	1.18	1.212	.93	1.26	1.16
Variance	1.47	1.32	1.88	1.39	1.48	.86	1.58	1.34
Range	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Minimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Research Question 2

In answering the question “Using a thin client (non-server based) object based delivery mechanism, is it possible to fulfill the requirements of the SIMREF using SCORM 2004 without any extensions?” required an analysis of the means of the SIMREF level variables SCORMEXT, SCROMSEQ, and SCO2SCO.

To provide a yes or no answer, first SIMREF level variables were developed from mean values of the corresponding requirement level variables. The variable SCORMEXT is the mean of the mean values of SCORMEXT1 (Req1) through SCORMEXT8 (Req 8). The variable SCORMSEQ is the mean of the mean values for SCORMSEQ1 through SCORMSEQ8. The variable SCO2SCO is the mean of the mean values for SCO2SCO1 through SCO2SCO9.

Next a set of descriptive statistics with histograms were produced for the SIMREF level variables SCORMEXT, SCORMSEQ, and SCO2SCO with careful attention paid to frequencies, central tendency, variance, dispersion, and range for anomalies such as dichotomy. From the descriptive statistics the means were examined for each variable for the condition $\bar{x} \geq 3.50$. If the condition was true for one or more of the three variables, then the answer would be negative.

Table 17 presents the variable means of SCORMEXT, SCORMSEQ, and SCO2SCO. The result of the descriptive statistics of SCORMEXT, SCORMSEQ, and SCO2SCO is also presented in Tables 17 and 18.

Table 17

SCORMEXT, SCORMSEQ, SCO2SCO Statistics

Statistic	SCORMEXT	SCORMSEQ	SCO2SCO
Mean	2.9705	3.1566	3.6209
Std. deviation	1.07562	1.14536	.89298
Variance	1.15696	1.31184	.79741
Range	4.00	3.50	3.13
Minimum	1.00	1.00	1.88
Maximum	5.00	4.50	5.00

From the data presented, SCO2SCO has a mean of > 3.50 thereby providing a negative or "no" answer. Descriptives of SCO2SCO show the smallest range and the smallest variance. After examination of the histogram, SCO2SCO seems to present some dichotomy in the data set with strong values on both the positive and negative sides with little neutrality. However, upon looking at the frequency counts the dichotomy is negligible with the strongest value occurring on the positive side of the scale. Both the histogram and frequencies of SCO2SCO are presented below.

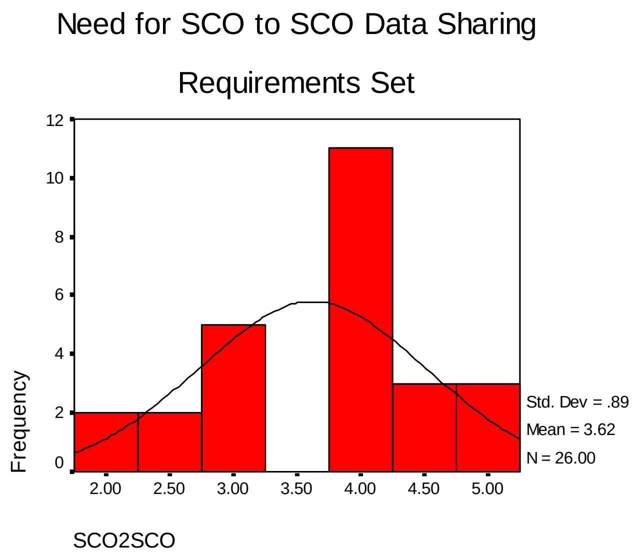


Figure 21. Research Question 2 Data

Table 18

SCO2SCO Frequencies

Value	Frequency	Percent	Cumulative Percent
1.88	2	7.7	7.7
2.25	1	3.8	11.5
2.50	1	3.8	15.4
2.75	2	7.7	23.1
2.88	1	3.8	26.9
3.00	1	3.8	30.8
3.14	1	3.8	34.6
3.75	3	11.5	46.2
3.88	2	7.7	53.8
4.00	3	11.5	65.4
4.13	3	11.5	76.9
4.25	2	7.7	84.6
4.50	1	3.8	88.5
4.75	1	3.8	92.3
5.00	2	7.7	100.0
Total	26	100.0	

Research Question 3

In answering the question "If extensions other than SCO to SCO data sharing are needed for SCORM 2004 to fulfill the requirements of the SIMREF what would they be?" first used the results of Research Question 2 to determine if extensions would be needed. As the answer was no, it was determined that in order to fulfill the requirements of the SIMREF using SCORM 2004 extensions would be needed. To answer the question "what they should be?" a qualitative analysis of open ended items 1 and 2 was performed with the following presentation of the findings.

Qualitative data were collected using the two open-ended questions (Open-ended Item 1, and Open-ended Item 2) at the end of the SIM SCORM 2004 Survey. Open-ended Item 1 asked the participant to list any current specifications or standards that could apply other than SCORM 2004 for fulfilling the requirements of the SIMREF. It also asked to describe those that would have to be developed. Open-ended Item 2 asked if there is a technology that would fulfill these requirements better, please list and describe it. Out of 26 participants in the survey six chose to respond to Open-ended Item 1 and 4 responded to Open-ended Item 2.

In the analysis of Open-ended Item 1, two categories were developed: current standards and specifications currently not a part of SCORM and capabilities needed that may not exist as part of current standards and specifications. For current standards and specifications not currently in SCORM, the following emerged (other than SSP):

Darwin Information Typing Architecture (DITA),

High Level Architecture (HLA),

Simple Object Access Protocol (SOAP),

None other than SCORM.

The answers varied widely by type and possibly by the participant's understanding of standards/specifications, SCORM, and the question. For example, one response supplied the IEEE CODE 1484.11.3-2005 which is the ECMAScript standard that SCORM is currently employing in its application programming interface (API). Also, even though it is still in use, another answered with the AICC HACP which is AICC's forerunner to the ECMAScript standard. In the other answers, the HLA is a standard for distributed simulations to communicate state data between them and the DITA focuses on content organization and modeling. The SOAP specification is a lightweight protocol for exchange of information in a decentralized, distributed environment using XML. The findings also included IMS SSP is a current specification allowing learning objects to arbitrarily share complex data between them or, in other words SCO to SCO data sharing in both open-ended items. This strengthens the argument for the need for complex arbitrary data sharing between SCOs but does not support the findings for this particular question.

For capabilities needed that may not exist as part of current standards and specifications, the answers were more consistent with each other and for the most part specific. These answers consisted of:

Support for the passing, storing, and retrieval of data values,

Support to track and provide global variables,

Support for if-then logic,

No standards needed at all, and

Industry-wide standards.

Data supporting the diverse understanding of the SIMREF and the Sim SCORM 2004 Survey is presented in the following quote:

> You don't need standards to accomplish these goals. You need a webserver that's visible to your learners and the ability for the content to send and retrieve data from said webserver. You also don't need SCORM 2004. You could do all the sequencing and pathing decisions within the simulation system itself. It seems to me that the only thing you need SCORM for is to communicate with the LMS -- and that's it. Everything else after that is a choice of how you want to architect your solution. Consider the costs and time to develop this solution (and maintain it). You haven't addressed reusability of any of the content, which would be the driver for me to use SCORM 2004. If re-use of content isn't a priority, I question the assumption that this has to be done in SCORM 2004.

In the analysis of Open-ended Item 2, four main categories emerged: research-based technology, current specifications as a technology, current web development technologies, and no better technologies exist. Within these categories several technologies were named and are presented in Table 19.

Table 19

Open-ended Item 2 Categories and Technologies

Category	Technology
Research-based technology	
	SITA (simulation-based intelligent training & assessment), a collaboration between Intelligent Automation and the US Army PEO STRI for a grant from the JADL
Current specifications as a technology	
	IMS Shareable State Persistence (SSP)
Current Web Development Technologies	
	Separate database calls
	Combination of PHP/MySQL, webserver, and XML
	Director
	Flash
None better	
	All current technologies in SCORM are adequate
	Use suspend data object in the CMI (SCORM)

From the above analysis, needed extensions to SCORM 2004 other than SCO to SCO data sharing (equivalent to SSP) consist of existing standards or specifications currently not a part of SCORM, capabilities needed that may not exist as part of current standards and specifications, and other technologies. The findings range from DITA, HLA, and SOAP, to the need for supporting the management and tracking of data values and global variables.

Research Question 4

In answering the question “Using a standard browser-based delivery mechanism, is SCORM 2004 sequencing adequate for fulfilling all of the requirements of the SIMREF? If not, what sequencing specific extensions are required?” first required analyzing the findings of the open-ended items for needed capabilities not currently existing within SCORM 2004 sequencing.

To provide a yes or no answer, the findings of the analysis of SCORMSEQ were used. As this analysis was presented in the prior discussion of Research Question 2, it will not be repeated. However, a histogram of SCORMSEQ is presented below.

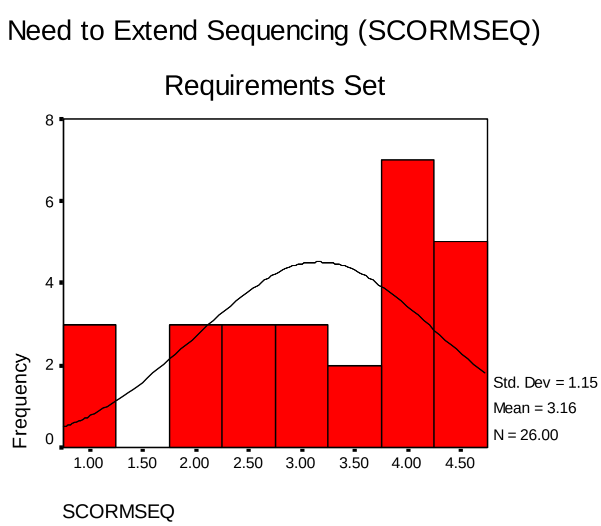


Figure 22. Research Question 4 Data

A negative answer required a condition of $\overline{X} \geq 3.50$. The mean for SCORMSEQ is 3.16. Based upon a condition of $\overline{X} < 3.50$ for SCORMSEQ, the answer to Research Question 4 was positive or “yes.”

Even though the answer was yes there were findings from the open-ended items that were relevant to extending sequencing. These included support for the passing, storing, and retrieval of data values, support to track and provide global variables, and support for if-then logic. These may be considered limitations in the IMS Simple Sequencing Specification (IMS GLC, 2003a; LSAL, 2004; Ostyn, 2007) incorporated within SCORM 2004 and, as such, were not unexpected.

Research Question 5

In answering the question “Using a standard browser-based delivery mechanism, is complex arbitrary data sharing between SCOs necessary to fulfill specific requirements of the SIMREF?” it required a assessment of the means of the requirement level variables SCO2SCO (1-8) to determine which of the requirements had a $\overline{X} \geq 3.50$.

To provide a yes or no answer, first a set of descriptive statistics with histograms were produced for the requirement level variables SCO2SCO (1-8). Important outcomes from these statistics were the mean, frequencies, standards deviation, and range values. For analysis, each requirement level variable was treated separately.

After producing the descriptive statistics, the means were examined for the condition of $\overline{X} \geq 3.50$ in all variables. If the condition was true for at least one variable, then the answer was positive. In addition, frequencies, standard deviation, and range of both variables were examined for normalcy and dichotomy in the results.

To answer the question with a "yes" required the condition $\bar{X} \geq 3.50$ to occur in at least one variable. This condition occurred in SCO2SCO1, SCO2SCO4, SCO2SCO5, SCO2SCO6, and SCO2SCO7. Based upon those conditions, complex arbitrary data sharing between SCOs is necessary to fulfill specific requirements of the SIMREF when using a standard browser-based delivery mechanism. Also, based upon the findings of the qualitative analysis, SSP (supporting SCO to SCO data sharing) was listed in both open-ended items as a specification or technology needed to fulfill the requirements of the SIMREF.

Based upon the descriptive statistics of SCO2SCO (1-8), there were some interesting data characteristics. For SCO2SCO2, even though the mean indicated neutral agreement, it was extremely close to being positive. If rounded up to an accuracy level of one decimal place, it would be positive with a 3.5. Also, SCO2SCO3 was dichotomous with no values falling into the neutral category. The histogram of SCO2SCO3 is presented below.

Table 20 and Figure 23 present the variable statistics. The result of the descriptive statistics of SCO2SCO (1-8) is also presented in the Table 20.

Table 20

SCO2SCO (1-8) Statistics

Statistic	SCO2-SCO1	SCO2-SCO2	SCO2-SCO3	SCO2-SCO4	SCO2-SCO5	SCO2-SCO6	SCO2-SCO7	SCO2-SCO8
Mean	4.23	3.48	3.17	3.72	3.52	3.80	3.80	3.12

Statistic	SCO2-SCO1	SCO2-SCO2	SCO2-SCO3	SCO2-SCO4	SCO2-SCO5	SCO2-SCO6	SCO2-SCO7	SCO2-SCO8
Std. deviation	1.07	1.29	1.52	1.06	1.48	1.19	1.35	1.33
Variance	1.14	1.68	2.32	1.13	2.18	1.42	1.83	1.78
Range	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Minimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

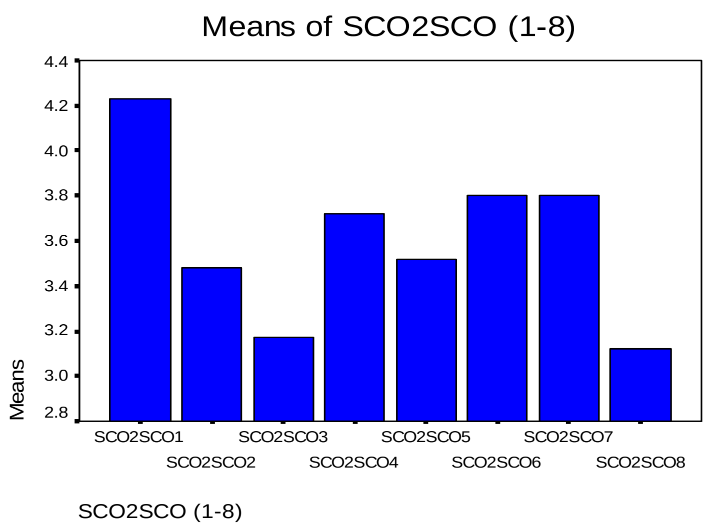


Figure 23. Research Question 5 Means

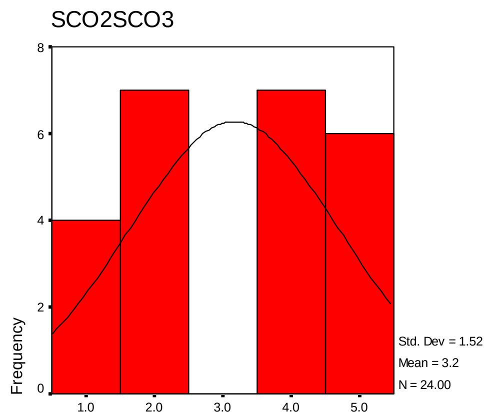


Figure 24. Research Question 5 Data

Research Question 6

In answering the question "Is it necessary to use customized LMS functionality and communications to fulfill specific requirements of the SIMREF?" required a comparative analysis of the means of the requirement level variables LMSCLIENT (1-8) to determine which of the requirements had a $\bar{X} \geq 3.50$.

To obtain a yes or no answer, first a set of descriptive statistics with histograms were produced for the requirement level variables LMSCLIENT (1-8). Important outcomes from these statistics were the mean, frequencies, standards deviation, and range values.

After producing the descriptive statistics, the means were examined for the condition of $\bar{X} \geq 3.50$ in all variables. If the condition was true for at least one variable then the answer was "yes." In addition, frequencies, standard deviation, and range of all variables were examined for normalcy and dichotomy in the results.

A positive answer requires the condition $\bar{X} \geq 3.50$ to occur in at least one requirement. This condition was not true in any of the requirements. Based upon a false condition the answer to Research Question 6 is that it is not necessary to use customized LMS functionality and communications to fulfill any requirement of the SIMREF. There were no significant anomalies in the data characteristics.

Table 21 and Figure 25 present the variable means. The results of the descriptive statistics of LMSCLIENT (1-8) are presented in the Table 21.

Table 21

LMSCLIENT (1-8) Statistics

Statistic	1	2	3	4	5	6	7	8
Mean	2.00	2.44	2.42	3.00	2.72	3.08	3.04	2.76
Std. deviation	1.22	1.26	1.18	1.53	1.31	1.44	1.49	1.27
Variance	1.48	1.59	1.38	2.33	1.71	2.08	2.21	1.61
Range	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Minimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Note: Due to space, column headings only include the number of the requirement level variable – i.e. 1 refers to LMSCLIENT1.

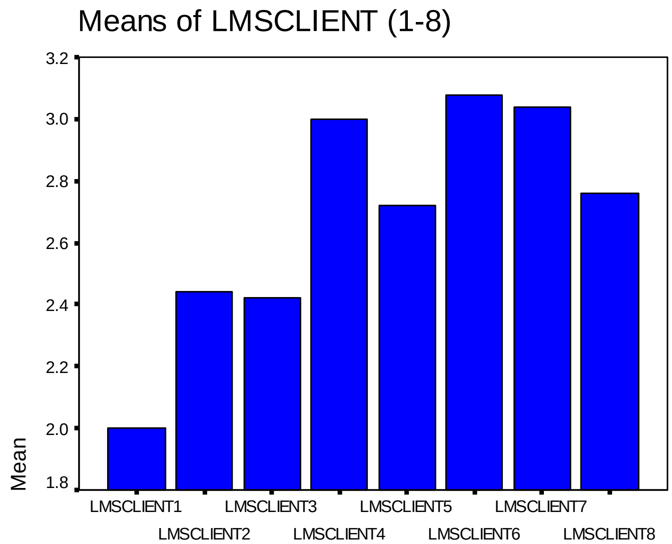


Figure 25. Research Question 6 Means

Research Question 7

In answering the research question "As gaps are identified in fulfilling the requirements of the SIMREF, do relationships exist between them?" requires the determination of any correlations or associations between variables. To begin answering the question, all SIMREF level variables were tested for normalcy using the Kolmogorov-Smirnov and the Shaprio-Wilk test for normality. Also produced were normal and detrended Q-Q plots, boxplots, and histograms. There were only two variables, SCORMEXT and LMSCLIENT meeting the assumption of independency and normalcy required for regressions testing. However, they did not meet the assumption of equal variances – 1.157 for SCORMEXT and 1.314 for LMSCLIENT. To determine if the other variables could meet the assumptions, they were each logarithmically transformed and re-tested. Those variables still failed to meet assumptions necessary for linear regression and, consequentially, could not be tested for regression.

As SCORMEXT and LMSCIENT met two out three of the assumptions and were close on variability, they were tested for linear regression testing with LMSCLIENT as the independent variable and SCORMEXT as the dependent variable. Linear regression means rejecting the null hypothesis that the population slope is 0 which also rejects the null that the correlation coefficient is 0. A strong correlation would mean values for the correlation coefficient close to 1 or -1. The results indicated a significant but weak positive correlation – correlation coefficient .588 and p = .001. As a significant correlation coefficient exists between LMSCLIENT and SCORMEXT, the null hypotheses that the population slope is 0 and the correlation coefficient is 0 are rejected.

Table 22

Coefficients(a)

		Unstandardized Coefficients	Standardized Coefficients			
Model		B	Std. error	Beta	t	Sig.
1	(Constant)	1.420	.428		3.319	.003
	LMSCLIENT	.588	.149	.626	3.937	.001

a Dependent Variable: SCORMEXT

To test for association which does not require assumptions of linear regression, the variables FUNCTSCO, SCORMSEQ, and SCO2SCO were recoded into the variables FSCOLEV, SEQLEV, SC2SCLEV respectively. The recoding of the values was as follows: 1-1.49 = 1, 1.5-2.49 = 2, 2.5-3.49 = 3, 3.5-4.49 = 4, 4.5-5 = 5. Next association was tested using symmetric lambda. From this test, no association could be determined between either of the variables.

Also, participants were grouped by SCORM 1.2 and SCORM 2004 experience levels for tests of correlation and association between each other and response to the primary finding of the relevance of SCO to SCO data sharing on five out of the eight requirements. These tests showed no relationships between the experience groups. It also showed no relationships between experience groups and SCO2SCO 1, SCO2SCO4, SCO2SCO5, SCO2SCO6, or SCO2SCO7.

Summary

This chapter has presented the data collected in both quantitative and qualitative forms and was organized by the research questions in the study. For each "yes or no" question, quantitative data were analyzed to obtain the answer. For questions asking "which ones" or "what type," qualitative data were analyzed and findings presented. To summarize the findings by research question, Table 23 lists the question and the findings.

Table 23

Research Questions and Findings

Research Question	Findings

Research Question	Findings
1. Are functional or typed SCOs necessary to fulfill specific requirements of the SIMREF? If so, which ones?	Functional or typed SCOs will be required to meet all of the requirements of the SIMREF.
2. Using a thin client (non-server based) object based delivery mechanism, is it possible to fulfill the requirements of the SIMREF using SCORM 2004 without any extensions?	It is not possible to meet the SIMREF requirements without extensions to SCORM 2004.
3. If extensions other than SCO to SCO data sharing are needed for SCORM 2004 to fulfill the requirements of the SIMREF what would they be?	Extensions that may be required other than SCO to SCO data sharing include the DITA spec, HLA standards, and SOAP specification, and capabilities for supporting the management and tracking of data values and global variables.
4. Using a standard browser-based delivery mechanism, is SCORM 2004 sequencing adequate for fulfilling all of the requirements of the SIMREF? If not, what sequencing specific extensions are required?	SCORM 2004 sequencing is adequate for meeting all of the requirements of the SIMREF. Potential extensions if needed would be support for the passing, storing, and retrieval of data values, support to track and provide global variables, and support for if-then logic.
5. Using a standard browser-based delivery mechanism, is complex arbitrary data sharing between SCOs necessary to fulfill specific requirements of the SIMREF?	Complex arbitrary data sharing between SCOs will be required to meet the requirements 1, 4, 5, 6, and 7 of the SIMREF.
6. Is it necessary to use customized LMS functionality and communications to fulfill specific requirements of the SIMREF?	It is not necessary to use customized LMS functionality and communications to meet the requirements of the SIMREF.

Research Question	Findings
7. As gaps are identified in fulfilling the requirements of the SIMREF, do relationships exist between them?	The null was rejected that the correlation coefficient between LMSCLIENT and SCORMEXT is 0. The correlation coefficient is .588 $p < .05$ indicating a weak positive correlation between LMSCLIENT and SCORMEXT. However, no other relationships exist between variables, experience groups, or between experience groups and the specific variables SCO2SCO 1, SCO2SCO4, SCO2SCO5, SCO2SCO6, or SCO2SCO7.

Chapter 5 will present a summary of the study and conclusions. It will also present discussions of the findings followed by implications and suggestions for further research.

5. Discussion and Recommendations

Summary

This study assessed SCORM 2004 for its affordances facilitating the implementation of specific requirements representing a simulation-based model optimized for interoperability and reusability. The overarching assessment methodology consisted of a gap analysis. A specific set of requirements called the Simulations Requirements Framework (SIMREF) derived from an existing online simulation learning environment was developed as the criterion and the Run-time Environment (RTE) and Sequencing of the SCORM 2004 technical architecture were targeted as the condition. To achieve the gap analysis, 26 experienced SCORM developers employed in industry, government, standards/specifications entities, and academia were surveyed.

Participants were asked to provide levels of agreement to indicator statements of the relevance of the SCORM 2004 technical architecture targets to the SIMREF requirements at both the individual and set levels. As such, data were collected and analyzed to determine the relevance of SCOs, functional or typed SCOs, extending SCORM 2004, extending Sequencing, relevance of SCO to SCO data sharing, and the utilization of a LMS thick client. Participants were also asked to describe alternate standards, specifications, technologies, and capabilities necessary to fulfill the requirements.

The findings from the data analyses indicated that according to the SCORM development community gaps do exist in the implementation of the SIMREF with respect to SCORM 2004 technical architecture as well as in common implementation practice. These gaps occurred within the communication affordances in the RTE and in the data value/variable management and if-then logic within Sequencing. Gaps are also present in the common implementation practice of using SCOs purely for content presentation. Also perceived by the community are potential gaps in the collection of standards and specifications that define SCORM 2004 in this particular case.

Conclusions

Based on the findings of this study the following conclusions can be stated:

1. It would not be possible to meet the requirements of the SIMREF in respect to SCORM 2004 without extensions. Specifically, it will be necessary to extend SCORM 2004 RTE to include arbitrary complex data sharing between SCOs. Potentially, it may be beneficial to extend SCORM Sequencing to better support the management and tracking of data values and global variables as well as the inclusion of if-then logic.
2. There are standards, specifications, and other technologies that could potentially be used to extend SCORM 2004 to allow the SIMREF to be met. These potential standards and specifications include SSP, DITA, HLA, and SOAP. Other technologies that may have potential to support the SIMREF were various web development technologies including Director, Flash, MySQL, and PHP.

3. The common practice of only developing SCOs as vehicles to present content will not suffice in this case. Functional or typed SCOs will be required to meet all of the requirements of the SIMREF. Such SCOs may not actually present any content at all but may contain only programming code or functions.
4. Although a common practice in integrating simulations with SCORM is to develop and implement a LMS-specific thick client providing specific communication functionality to a LMS, this technique would not be necessary to meet the SIMREF requirements.

Discussion

This section is organized by themes based on the conclusions presented in the preceding section. In addition, discussion about generalizability of SIMREF and findings of the assessment will be presented.

Gaps in Capabilities

The SIMREF contains eight requirements describing functionality necessary to support a simulation-based learning environment. The functionality represented by these requirements supports learner introduction and initial setup; tracking learner profile changes, status and progress; furnishing and receiving simulation input and output data to other systems; providing simulation state feedback to the learner; providing contextual decision-making information to the learner; providing contextual decision coaching to the learner; and providing end-of-period reflection input and storage capability per learner.

Providing contextual and decision dependent functionality requires the broadcasting of status data by some systems and the ability to make sense and act on that data by others. In this case, a specific system would be contained "black-box fashion" within a SCO as a functional SCO. Implicit within the implementation of these requirements is the need to communicate data between SCOs. Also implicit is the potential need for SCO's to persist (co-exist during runtime) - currently not allowed in SCORM.

The argument could me made that SCORM (all versions) allows this communication now through the Run-time Environment (RTE) using the API and the CMI data model. While this may be true to some extent, the CMI data model is a pre-defined somewhat limited model designed to communicate event data to a LMS about events occurring within a SCO. For example, it can communicate a learner's score compared to a preset mastery level indicating whether or not a learner has "passed" the SCO or it could communicate whether or not a learner has "finished" the SCO. It can also communicate other types of SCO related event data including the learner's location within the SCO (i.e. bookmark using the *cmi.location*[1] object). The *cmi.location* object has historically been used for multiple communication purposes and has been suggested as a communication solution to the SIMREF from one participant.

Another capability that could be considered in this context may be the CMI data model's ability to communicate a stream of interaction data using the *cmi.n.interaction* data object. A specific class of interaction called a performance interaction (*cmi.n.interaction.performance*) can track and communicate up to 125 specified and ordered Boolean events. This has the potential of assessing and scoring a learner in a simulation contained within a specific SCO. However, with only 125 Boolean pre-

[1] The CMI data model uses dot notation indicating objects, identifiers, children, and/or type – i.e. interaction.n.performance where "interaction" is the object, "n" is the identifier, and "performance" is the type.

assigned and pre-ordered events, this method may not be robust enough for communicating rich state data snapshots produced by a simulation engine. Other potential CMI objects for storing and retrieving state data are the cmi.launch_data and cim.suspend_data objects. However these and the previous CMI objects, besides being limited in capacity, produce data that can only be read by the SCO producing it. In other words, there is no SCO to SCO communication.

As one of the goals of implementing the SIMREF is not only interoperability but reusability, the above solution may have another serious flaw. In using the CMI model for communication, data would have to be pre-defined either as strings or as arrays of Boolean data hard coded as read-only data within the content package and/or stored by the Run-Time Environment (RTE). Even if the data could be communicated to other SCOs, this would create a tightly coupled situation severely reducing reusability.

SCO to SCO data sharing is discussed as complex arbitrary data sharing in the IMS Shareable State Persistence (SSP) Data Model version 1.0. It is presented as a SCORM extension and describes how the SSP Information Model and its abstract application programming interface (API) are bound to[2] the SCORM Run-Time API using dot-notation. It is complex because it allows data sharing between complex interactive content as in a simulation. It is arbitrary because it allows content objects (i.e. SCOs in the SCORM lexicon) to request allocation (from the runtime service) of an arbitrary number of independent data “buckets” and access those buckets. In this specification, additional data sharing support include the accessibility of persistent data buckets by

[2] The term “bound to” refers to the mapping, synchronizing, and transporting of data. It is also considered a definition of behavior that can be applied to a data element.

other content objects and storage requirements of the content object's data buckets that can be explicitly specified as discoverable properties not requiring the content object to be launched (IMS GLC, 2006).

In other words, the IMS SSP would allow a SCO to define its data storage requirements, store its data in a persistent manner, and allow other SCOs to access and use the stored data as needed. This would accomplish SCO to SCO data sharing and greatly facilitate reuse by encouraging the development of functional SCOs as components in a loosely coupled manner much like that of a Service Oriented Architecture (SOA).

The need for SCO to SCO data sharing has been confirmed with the results of this study (SCO2SCO or SCO to SCO data sharing being deemed relevant in five of the requirements). Although the relevance rating of SCO to SCO data sharing to each requirement could logically be affected by the SCORM experience of the respondent, this could not be confirmed. A much larger amount of data would most likely be required for these types of relationships to emerge.

Although the findings determined that extending SCORM Sequencing would not be necessary to fulfilling the SIMREF, qualitative data suggested differing levels of agreement and offered specific suggestions. These suggestions encompassed the support for the management and tracking of data values and global variables as well as the inclusion of if-then logic.

The SCORM Sequencing and Navigation book discusses the inclusion of global objective variables with both Boolean or numerical data value storage and tracking capability. It also discusses the if-then model used to determine sequencing rules.

However, as a programming language it is very limited. Conditions are relegated to True or False with the exception of the Objective Measure (-1 - +1 values) and types are limited. Resulting actions are also limited in type allowing essentially only navigation decisions. Sequencing conditions and actions are presented below in Figure 26. Also, conditions are evaluated from either pre-set "flags" hard coded in the content package or by values contained within the Objective variable. The perception of coding and implementing these sequencing rules may be that they are too low-level much like the difference between an assembly language and higher-level languages in computer programming.

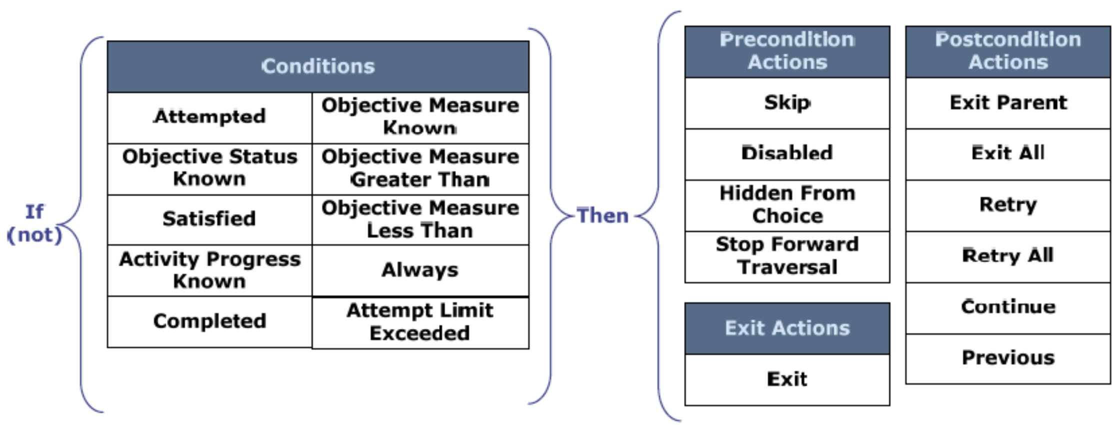


Figure 26. Sequencing Rules, Conditions, and Actions (ADL, 2006c)

Potential Standards and Specifications for Inclusion

In the findings, other standards and specifications were presented as potential supplements to SCORM 2004 in meeting the SIMREF. Besides the IMS Shareable State Persistence (SSP) addressed in the preceding section, three others were suggested. These were the Darwin Information Typing Architecture (DITA) OASIS Standard version 1.0, the High Level Architecture (HLA) IEEE Standard 1516-2000, and the Simple Object Access Protocol (SOAP) version 1.2 W3C Specification.

DITA was suggested as an alternative to SSP to fulfill the SIMREF requirements. DITA is a content structuring and display technology based upon a combination of Minimalism instructional design, Information Mapping, and Sequential Thematic Organization of Proposals (STOP) (Organization for the Advancement of Structured Information Standards Darwin Information Typing Architecture (DITA) TC [OASIS DITA], 2005). Minimalism emphasizes streamlining of instructional materials and a task-based approach to the organization of manuals, tutorials, and other instructional content. Using content organization, Minimalism's goals fall in line with the concepts of andragogy supporting actions, documenting tasks, helping to avoid errors, and supporting exploration (OASIS DITA, 2005; Rosson, Carroll, & Bellamy, 1990). Information Mapping is the practice of chunking information into small manageable pieces based upon its type. The types used are typically those of concepts, facts, processes, procedures, and principles (Horn, 1998). In STOP, subject matter is organized into relatively brief themes, each presented in a module of two facing pages complete with an associated graphic (Tracey, Rugh, & Starkey, 1965).

DITA as evidenced by its own documentation and the theories that it is comprised of, is a content structure standard with a goal of facilitating the broad reuse of content by various domains and organizational structures. What is does not do is to facilitate persistent communication between content objects. It is interesting that this standard was suggested because of it direct ties to and facilitation of the transmission of content as a learning model. This suggests that those working within the standards community still may not be thinking about other models of learning and other definitions of what learning "content" may be – e.g. problem presentations, random access to learning resources as needed, or exploratory environments.

The IEEE High Level Architecture standard provides a general framework within which simulation applications can be structured and described. As with SCORM, the HLA is designed to facilitate reusability and interoperability. In this case reusability addresses the reuse of models in different contexts and interoperability addresses the communication between simulations. There are two main components forming the HLA. First is the Object Model Template (OMT), which describes the data used by a particular model (i.e. simulation), and facilitates reuse. The second component is the Federate Interface Specification, describing a generic communications interface allowing simulation models to be connected and coordinated, addressing interoperability. HLA uses runtime infrastructure (RTI) software required to support operations of a federation execution. The RTI software provides a set of services, used by federates to coordinate operations and data exchange during a runtime execution (DMSO, 2006; IEEE, 2000).

In addressing the HLA as a potential extension to the SCORM to better facilitate simulations requires an examination of HLA's purpose. By the above definition, the HLA is designed to support a distributed simulation environment or, as described by both DMSO and IEEE, a "federation" of simulations. This might describe a macro simulation environment where there are multiple actors (learners) performing individual tasks or roles on different types of dedicated micro simulation components. These micro components are stand-alone simulations in their own right but joined together using HLA to create this larger environment. An example of this from the DoD training realm could be a federation containing a flight simulation, a ground vehicle driver simulation, a command and control simulation, and a individual weapon simulation. These multiple simulations could be coordinated in a common scenario with output from each affecting the scenario and registering relevant changes on each specific simulation.

As identified in this study, to meet specific requirements of the SIMREF, SCORM would need SCO to SCO communication. This would involve the persistent storage and retrieval of potentially large amounts of state data from a simulation engine embedded within a SCO. These data would then have to be made available to other SCOs performing various functions. These functions include provisioning contextual information for decision support, user feedback on the state of the simulation based upon specific parameters such as available budget, and user coaching based upon simulation conditions and decisions made. The HLA may provide an option for this type of communication if implemented between SCOs. However, besides potential confusion of integrating its object model into that of the SCORM CAM, it would require the addition of its RTI which would be in direct competition with the SCORM RTE. Also, it is not clear from the specification if the RTI supports persistent arbitrary data storage and retrieval at the local level.

There is ongoing research into this integration using an approach that does not directly integrate the HLA into the SCORM LOCM but integrates with it in a more side-by-side approach. In research undertaken by collaboration between Intelligent Automation, Inc. and the US Army PEO STRI, Java applets are used to interface between SCOs (SCORM) and a simulation manager/RTI interface (HLA). This has been developed as the Simulation-based Intelligent Training and Assessment (SITA) architecture and has successfully integrated a simulation federate with different SCOs supporting and tracking different simulation-based learning activities (Haynes, Marshall, Manikinda, & Maloor, 2004).

The SITA approach works when treating simulations as a separate entity utilizing a translator between the HLA and SCORM specifically for the simulation federate and SCOs utilized. If the simulation and its learning environment is defined by and implemented using collections of and types of learning objects or SCOs striving for maximum component reuse (as is the intention of the SIMREF), this approach may fall seriously short. In other words, treating a simulation as an outside entity to be interfaced with may work in a single case but may break down as more complex learning environments need to be developed and their components reused.

The SOAP specification could hold promise as an extension providing SCO to SCO data sharing capabilities if data could be stored and accessed persistently. SOAP is intended to exchange structured information in a decentralized, distributed environment using XML technologies. It is also an important component in the definitions and implementations of web services which is a primary technology for implementing service oriented architectures (SOAs).

SOAP works by utilizing HTTP (hypertext transport protocol) to transmit or receive messages (i.e. data) embedded in an XML envelope. Transmissions are targeted towards defined URIs (universal resource identifiers and superset of URL) usually requesting the use of a particular function and passing it parameters to act upon (Refsnes, Refsnes, & Refsnes, 2007; W3C, 2007b). However, for SOAP to be included as a communication protocol between SCOs as a solution to the SIMREF, a persistent component other than a SCO would have to exist as a relay or SCORM would have to modify one its primary tenets. The modification would consist of allowing more than one SCO at a time to be launched and tracked by the SCORM RTE. The existing limit of launching only one SCO at a time is a cause of the need for persistent data storage and retrieval.

Other technologies that could potentially support the realization of the SIMREF besides standards and specifications consisted of web development technologies including Flash, Director, MySQL, and PHP. These could be characterized as multi-media development technologies (Flash and Director) and back-end development technologies (MySQL and PHP). Both categories are important and ubiquitous for the development and implementation of e-learning solutions. However, in terms of SCORM, their importance mainly lies in the development and presentation of the actual learning content comprising either SCOs or Assets. It is not clear that there would be any direct advantage of these technologies to solving the problems of SCO to SCO data sharing or in contributing to more robust sequencing capabilities.

Implementation Requirements

SCOs are commonly developed as vehicles to present content and usually consist of the display and manipulation of text and graphics. They are typically not thought of as performing a specific reusable function or offering a capability for other SCOs to make use of. The findings suggested that all eight requirements of the SIMREF would need a purely functional SCO for implementation. Designing functional SCOs would require a change in how SCORM is typically implemented. This implementation would mean that a SCO contains code for acting on incoming data and sending it back out much like a service in a SOA and may also have a user interface (UI) for directly or indirectly interfacing with the user (learner) as well.

An example of this might be Requirement 3 of the SIMREF, “Data flows as input and output from an embedded simulation.” In this example, the SCO contains a simulation engine processing “what if” data and actual decision data from the user (learner). “What if” impact data is available as output to other systems that may display the impact data to the user to evaluate potential decisions or perform other functions. Decision data, impacting the state of the simulation, is available as final results of the decision to other systems for evaluation and display to the user. Therefore, the simulation engine only acts on or processes data based upon user input and internal code and algorithms communicating with other systems for other processing including displaying reports, evaluating remaining budget, viewing simulation status, or coaching.

The other requirements of the SIMREF also imply specific functionality including activities such as role and scenario choice, scenario or backstory presentation, and collecting and tracking of learner reflections. As a set, all eight requirements function together to complete the functionality of the simulation learning environment.

The value of having SCOs perform specific functional behaviors is that these SCOs can function independently of each other creating a loosely coupled environment. Also, the context is in the collection of the SCOs and how they behave together not in the individual SCOs. It is in the collection of these types of SCOs that can come together to define a pedagogical model. Designing is this manner allows SCOs to have smaller granularity and greater abstraction. Combined with loose coupling, these tenets give the SCOs high reusability for inclusion in different learning environments. Different learning environments could be based on pedagogical models such as another simulation or other pedagogical models giving the designer the ability to design using models of learning.

For example, if designing an exploratory troubleshooting learning environment as described by Jonassen and Churchill (2004), potentially the same types of SIMREF functionality could be applied or reused. The troubleshooting learning environment consists of a case library of previously solved problems, a troubleshooter that enables the learner to practice troubleshooting, and a conceptual model of the system being troubleshot. “Learning objects could be articulated for each of those - conceptual model objects, troubleshooter objects, and case library objects” (Jonassen & Churchill, 2004, p. 39). The preceding quote illustrates that functional or typed learning objects would be needed to fulfill the troubleshooting learning environment.

In keeping with the troubleshooting learning environment scenario, through repurposing or direct reuse, SIMREF functionality could be applied. Areas of application could be to the Conceptual Model accessibility, functions of the Troubleshooter such as “action,” “results,” and “interpretation” as well as Case Library support. A high level diagram of the Jonassen and Churchill model is illustrated in Figure 27.

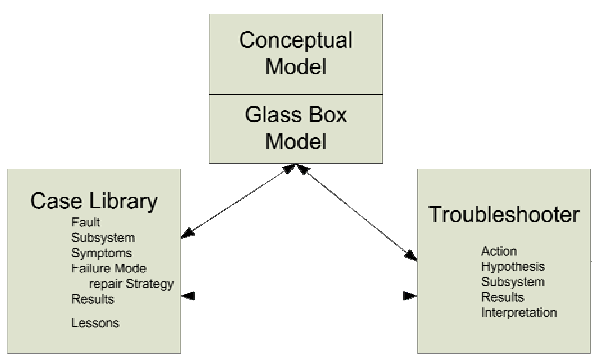


Figure 27. Troubleshooting Learning Environment Model (Jonassen & Churchill, 2004)

To allow discovery enabling reusability of functional or typed SCOs, the application of either extensions to the IMS metadata model if used or in the current applied metadata model would be required. These extensions would support the typing or describing SCOs based upon specific functionality supporting search and discovery during the authoring process or during delivery.

Besides describing functionality, typing could also facilitate the support, use, and reuse of specific types of learning models. For example, SCOs could be developed supporting the use of simulations, or other models including problem-based learning or case-based learning. As a designer is applying a model to a learning solution, SCOs could be discovered based upon pedagogical model type and applied either as is or through repurposing. This would impact design, authoring, and reuse, however, as SCOs supporting one type of pedagogical model or applied instructional theory may require different levels of abstraction and granularity thereby constraining them to possibly only one model. An example of this would be designing SCOs for Component Display Theory where small granularity size and less abstraction might be ideal. This could be in contrast to designing for Instructional Transaction Theory where specific instructional strategies and knowledge objects may require a radically different rationale for the granularity and abstraction which also could be in direct contrast to designing for problem-based learning, situated learning, generative learning, and other models.

In the context of pedagogical models and applied instructional theory, it is not surprising that granularity and reusability of learning objects may be seen as orthogonal. Currently, ADL does not endorse the use of SCO typing as it is seen to lower reusability. However, in essence, it allows the units of reusability to include other things besides

SCOs into the realm of pedagogical models implemented at the activity level of the CAM.

Also, in practice even traditional content-based SCOs are not typically designed to offer much reusability. A lack of “designing for reuse” is most likely due to the influence of traditional instructional design’s approaches, strategies, and goals. Instructional designers are trained to approach design in terms of a complete solution for meeting an identified set of learning or performance goals and/or objectives as a single context. Also, instructional designers may fall into the trap of allowing the affordances of most online learning authoring tools and object models to dictate design - commonly a one-way transmission model of learning supporting declarative knowledge acquisition. When translated into a SCORM-based course, designers still think of the course or module they design as a cohesive unit with content breaking down into smaller units of disaggregation – i.e. courses, modules, units, lessons, and topics. This breakout is typically described by the SCORM CAM as either clusters of activities, activities, and SCOs. Unfortunately, the above breakdown is a common practice as described by the Learning Systems Architecture Lab in their SCORM Best Practices Guide for Content Developers (LSAL, 2004). However ADL does not advocate this tradition as it is recognized to severely limit design and reusability.

To combat this tradition of non-reusability, designers will have to begin designing for reuse. This will include systems thinking at the macro of “course” level as well as at the micro or SCO (learning object) level. They will need to begin thinking not only about instructional purpose but the functionality supporting instructional purpose and how it supports the pedagogical models they are using. Also, understanding how enterprise IT (information technology) learning tools such as LMSs function in high level terms and what their goals and purposes are may help instructional designers better understand not only their emerging toolset but why reuse needs to occur.

A common practice in integrating simulations with SCORM is to develop and implement a thick client that provides specific communication functionality to a LMS but was determined not to be necessary to meet the SIMREF. This technique is similar to that described in the SITA implementation as it uses a simulation engine external to the SCORM environment and the thick client is treated as a SCO being the liason between the simulation and the LMS. This solution breaks down in several ways. First, a thick client is more than a standard web-browser potentially creating interoperability and bandwidth issues for the user. Second, as in the SITA approach, it treats the simulation as an entity external to the learning environment, and third, accessibility is severely limited as the simulation engine exists on a remote server.

In contrast to the above techniques and to SITA, a purely SCO-based solution as outlined in the SIMREF contains a simulation engine existing as a SCO with other simulation support functionality existing as other SCOs. The content package containing these SCOs would be downloaded at the point of use creating the potential for off-line use with LMS synchronization occurring at a later time.

Implications and Recommendations

From the conclusions reached and the ensuing discussion, there are several implications from this study that could result in recommendations for the SCORM 2004 specification and implementation practices. First, in order to accommodate a simulation encapsulated in a content package, SCORM functionality should be extended in facilitating inter-SCO communication. The logical technology to accomplish this type of communication is IMS Shareable State Persistence (SSP). Although other standards and specifications exist, as a learning object content model (LOCM) comprising of a collection of specifications and standards, SCORM 2004 would benefit from including the SSP specification as permanent component.

SCORM Sequencing may benefit from tools supplying high level programming language capabilities for authoring or developing sequencing logic for SCOs. The IMS Simple Sequencing Specification itself may benefit from extensions to its if-then logic and the inclusion of a more robust set of actions.

Designing for reusability could occur at macro and micro levels when using SCORM or any other LOCM. These levels include the SCO or learning object, SCORM activities, and other representations of pedagogical models. In the relationships between these components or levels, this approach could be used to determine their necessary level of abstraction and granularity size. This potentially may enable the development, use, and reuse of advanced pedagogical models.

The way SCORM is implemented currently should change to include the addition of functional and typed SCOs. This implementation would be facilitated by the addition of SSP to SCORM. By implementing this change to current practice, designers and developers would need to change the way they approach and think about design and development to include both macro and micro systems approaches and an understanding about enterprise learning technologies and what is gained by designing for reuse. This change implies that the educational programs for instructional design and instructional technology may need to change to accommodate systems thinking, reusability design tenets, and enterprise approaches to e-learning and knowledge management. Also implied is the need for a closer marriage of information technology and instructional technology in the preparation of instructional designers and IT developers working in the instructional technology field. This marriage should focus developers to work closely with designers to understand and translate learning designs into functionality.

Typically, graduates from instructional design and instructional technology graduate programs do not possess understanding in design perspectives encompassing reusability. They also do not have an understanding of design in an enterprise environment and/or the underpinning technologies of learning objects, learning object content models, and enterprise learning systems. Also, typically, graduates from computer science (CS) or information technology (IT) undergraduate and graduate programs do not have an understanding of how CS and/or IT supports and facilitates learning. This condition is illustrated by the response patterns within the sample of this study. For those with experience primarily in IT, responses were closely aligned across all requirements which tended to be the opposite of responses by those whose primary experience was that of instructional systems design. Also, the answers from the open-ended items concerning alternate solutions only came from those with IT experience.

A lack of understanding typically present in instructional designers may be due to the focus on learning theory, instructional design processes, and instructional strategies and not on the technological and enterprise landscape in which these theories and processes will be applied. This occurs assuming that as they build an instructional plan, a programmer will then implement their plan in some environment possibly not knowing anything about what that environment may consist of or how it will impact or be impacted by other environments.

A lack of understanding by those in CS or IT may be due to the focus on the gathering of requirements and building of systems based upon those requirements – not from the generation or theoretical understanding of the gathered requirements. When working together to design and implement enterprise learning technologies, requirements generation actually occurs during the design by instructional designers with the implementation of those requirements occurring during system development by system and software engineers. This dichotomy leaves a gap in the understanding necessary for optimum design and development of enterprise learning technology systems. As instructional designers work closely with developers, an understanding needs to occur about the role each has to play in designing and implementing reusable, functional SCOs and pedagogical models. To bridge this gap, curriculum development and evaluation of a blended field of instructional design/technology and computer science/information technology should occur. Graduates from the curriculum could function as instructional architectures or instructional engineers designing and applying research derived models to solve enterprise learning problems.

Most specifications and standards including those from AICC, IMS, DMSO, the IEEE LTSC, ARIDNE as well as SCORM, have been designed by IT developers who may not be native to the field of education and training and may not have a deep understanding of learning theory and practices. In fact, most of those that are and have been heavily involved with the design and evolution of SCORM come from the electrical engineering, computer science, and other technical fields.

The design of the CMI data model (incorporated into SCORM from AICC) reflects a behaviorist model in the learner interactions supported and types of data stored and tracked. The limited CMI data types include (among others) completion of a SCO presented to the learner, objectives, scores, and interactions. Multiple interactions exist within the CMI including multiple-choice, short and long text fill-in and even performance types. However, the interactions and the data types in the model represent only what can be collected through a learner's response to a given stimulus and is usually quantitative in form. In practice, this collection usually occurs through the presentation of information, the presentation of questions on that information, and the responses of the learner to the questions. Responses are gathered using the interactions and are evaluated for score or pass/fail which is sent via the Run-time Environment (RTE) to be stored in the LMS. This occurs at the SCO level and learning is only tracked by the LMS by the completion or passing of a SCO. In this fashion, there are some comparisons to programmed instruction or even mastery learning.

Prior to SCORM 2004, SCOs were commonly available to a learner to take in whatever order they wanted. This was seen as an attempt to support a more exploratory learning environment with learner self-direction. With SCORM 2004, SCOs can also be sequenced based upon pre-defined rules which are based upon the attainment of learning objectives defined globally within a SCORM course. The sequences of SCOs are set up in a score threshold or pass/fail navigation model which still supports mainly an objectivist view of learning.

The limitations of the CMI do not govern what occurs instructionally within a SCO, but it limits what can be communicated by a SCO to the outside world. For example, a single SCO could have a complex simulation with a 3D user interface (UI). A learner could interact with the SCO at length but the only data communicated by the SCO would be limited to the CMI data model. It would not be possible for the rich data set that would be produced in this case to be utilized as evidence of competency attainment or understanding. This limitation in combination with the lack of SCO persistence, a limited model of sequencing, and the individualized nature of SCORM reflects an inability to support constructivist learning tenets such as alternative assessments and activity-based learning.

In all fairness to SCORM, however, these limitations are embodied in most all online learning environments utilizing a learning object content model for individualized self-paced instruction and may not be only due to the model itself but also to common instructional design practices. By not having a thorough understanding of what is capable within a LOCM such as SCORM, instructional designers fall back on easy to design and easy to program models that end up as what is commonly referred to as "page turners."

These conditions may explain why the inherit pedagogy supported by SCORM is one primarily based upon information or content transmission. It may also explain the differences in the responses from study participants depending on where their experience lies. If applied learning theorists and those versed in fields such as instructional design, instructional technology, and educational psychology had been more involved in its inception, models supporting more meaningful learning experiences may more easily be supported and applied by SCORM. Consequentially, specifications and standards comprising SCORM and their implementation practices reflect an underlying pedagogy that is based in behaviorism, does not agree with contemporary theories of learning and practice, and will not support more constructivist models learning - i.e. simulations.

As SCORM moves into its next evolutionary state through the formation of its new steward tentatively named Learning Education Training Standards Interoperability (LETSI), it is time to actively reach out to the academic community for support, critique, and inclusion. This overture would help ensure that future iterations of SCORM not only support but embody current understandings about learning and pedagogy. However, in so doing, the academic community also needs to see the need and value of designing and implementing in an efficient and cost saving manner. The academic community also needs to understand how to incorporate reusability and interoperability in the artifacts of instructional design and not dismiss these tenets as not relevant or completely orthogonal to good instruction and meaningful learning.

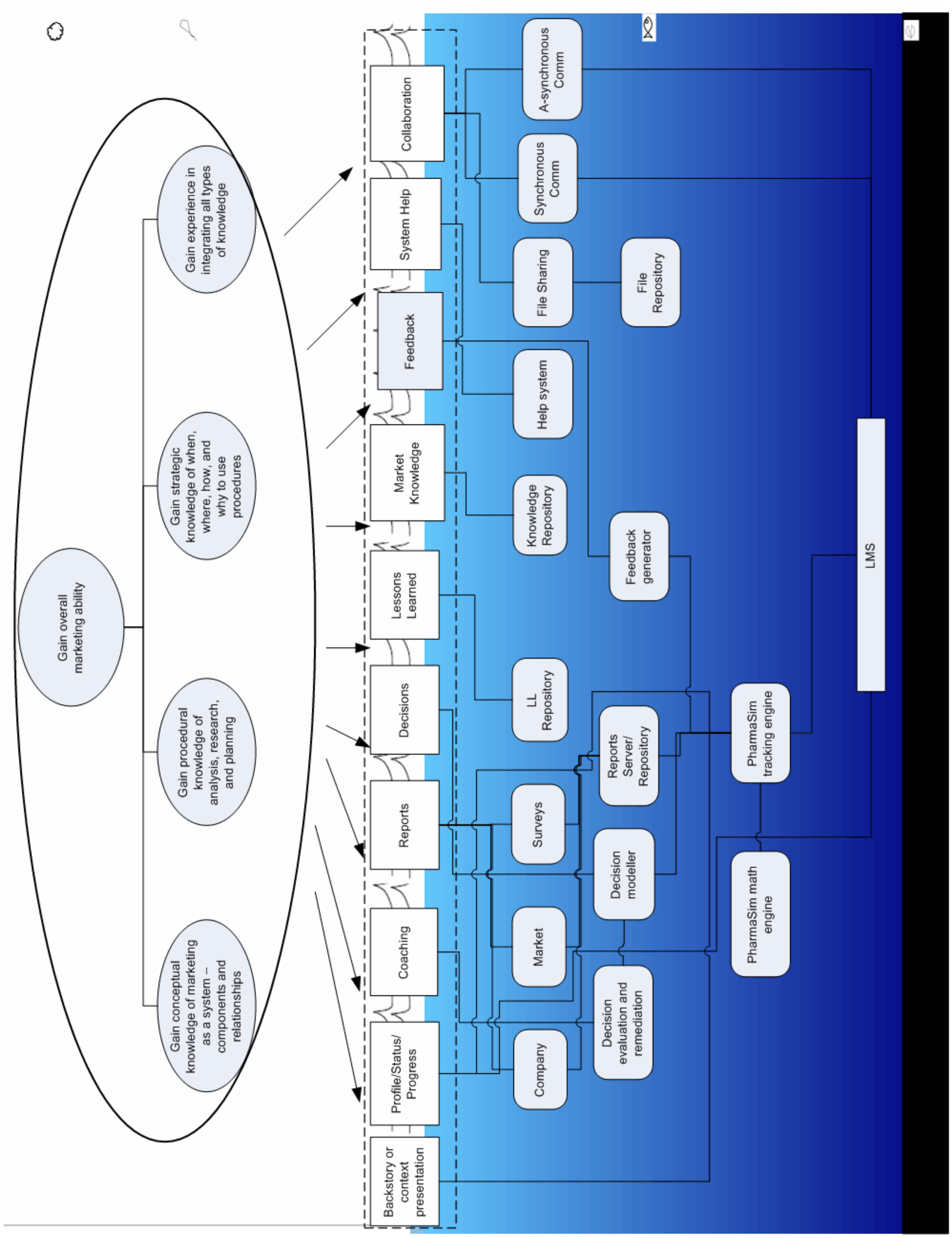
Further Research

In support of the preceding implications and recommendations, there are areas to be considered for further research. First, in furthering the needs of simulations in online learning, empirical work on developing a robust inclusive taxonomy of simulations should be developed. Following this, archetypical requirements frameworks should be developed for the taxonomy nodes and assessed against SCORM. This assessment may help determine if other simulations have differing needs from a LOCM. Other pedagogical models should also be defined, requirements frameworks developed and used to assess SCORM for their needs. This area of research would then begin to give direction to the evolution of SCORM and other LOCMs.

Other areas in need of further research include the effectiveness of implementing and reusing functional or typed SCOs in terms of their actual reusability and their ability to function within and support specific pedagogical models. Also, included should be definitions and applications of pedagogical models and their components. It would be beneficial to research the effectiveness of these models as applied in learning environments and if and to what extent they are reusable. Finally, a necessary area of research would be to design and evaluate curriculum supporting a graduate program intended to bridge the gap between instructional design/instructional technology and information technology/computer science. Such a program would have intended learning outcomes supporting the understanding of the convergence of these fields, designing for reuse, and the application of learning technologies within an enterprise.

Appendix A

UML Level Diagram



Appendix B

Simulation Requirements Framework (SIMREF)

Requirement 1: user selects their role and chooses a scenario within the simulation-based course.

Sub-level Components:

- The learner has logged on to the LMS and has chosen the simulation-based marketing course; user creates profile by choosing one of three roles and one of five scenarios.
- User role in the simulation will be progressively upgraded by default (i.e. assistant brand manager to brand manager) as determined by simulation performance, unless user disables default option.
- After making selections, user submits form.
- After submitting form, welcome page and case (scenario overview) are displayed and simulation play begins.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO

Requirement 2: user views case (scenario overview) and is welcomed to the course.

Sub-level Components:

- If new user, case is initially presented as a static story using text, graphics, and animations.
- If returning user, case access is optional.
- Case will be available to other entities outside this simulation who are seeking marketing domain knowledge.

Requirement 2 refinements and assumptions:

- The learner enters the course. If this is the first attempt by this learner in the course, then content called the "case" (hosted by a knowledge base as part of the course) is presented that provides an overview of the scenario. Subsequent reentry into the course resumes the previous attempt. The learner is allowed to view the "case" at will after they initially experience it.
- Scenario interacts with simulation behavior affecting such things as "budget."
- It is assumed that this requirement is fulfilled by at least one dedicated SCO

Requirement 3: Data flows as input and output from an embedded simulation.

Sub-level Components:

- User will input "what if" data. This is data used for modeling decisions having no direct impact on the actual state of the simulation.
- User will input decision data. This is data that will impact the state of the simulation.
- Non-impact "What if" results data is available as output.

- Period final results data is available as output.
- It is assumed that this requirement is fulfilled by a dedicated SCO with an embedded simulation engine.
- The SCO will not be required to communicate with an external system.

Requirement 4: User views available reports contextual to the scenario, and simulation progression.

Sub-level Components:

- After user has created a profile and has viewed Case/welcome, reports become available and displayed built on data from the simulation.
- Availability of user to have specific reports displayed is directly tied to the state of the simulation.
- Specific reports may only be displayed after being "purchased" by the user.
- User report purchasing ability depends on the available budget supplied from the simulation.
- Purchasing a report debits budget data within the simulation.
- Reports will be viewable, printable, sortable, graphable, pivotable.
- All reports will be available to other entities outside this simulation who are seeking marketing domain knowledge.

It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Requirement 5: Budget feedback system.

Sub-level Components:

- Feedback will be provided to users during the simulation "what if" phase.
- Feedback will be immediate.
- Alerts will be provided when users exceed their available budget based upon budget data from the simulation.
- Feedback will be available and determined based upon reports visited and/or reports purchased.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Requirement 6: user views status.

Sub-level Components:

- User is able to persistently view simulation progress by period (1-10).
- Simulation progress data will be tracked by the LMS.
- User is able to persistently view summary status reports by period built from simulation state data.
- Summary status reports include cumulative periodic simulation data such as progressive performance and financial data.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Requirement 7: coaching system is available upon request.

Sub-level Components:

- After User has created profile and has viewed case/welcome, a coaching system is available to that user when modeling or making decisions within the simulation.
- Coaching system communicates with the simulation to monitor user input and simulation output.
- As requested by the user, coaching will provide (display) decision making information to the user pertaining to the type of decision and the potential outcome of that decision the user is about to make in the simulation.
- As requested by the user, coaching will provide (display) decision making feedback depending on the impact of the decision being made by the user when modeling a decision (simulation "what if"), based on an expert decision rubric.
- The coaching system will provide access tracking data back to the LMS.
- Coaching will be made available to other entities outside this course.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Requirement 8: user provides end of period reflection.

Sub-level Components:

- User must complete and submit a reflection write up using a pre-specified template before the simulation will be allowed to advance to the next period.
- Submittal data will be tracked by the LMS. Reflections will not be available to other users.
- Users will have access to a periodic rubric to gauge their thinking.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Appendix C

Sim SCORM 2004 Survey

Simulation/SCORM 2004 Survey

Introduction

To better understand the gaps of SCORM 2004 in relationship to developing and integrating simulations within the SCORM environment, an online simulation called PharamSim was used to develop a baseline requirement set. These requirements represent the requirements necessary to field an online simulation delivered as a complete SCORM 2004 content package. As such, the extracted requirement set represents an analysis of the functional areas and user/system interactions necessary for the functionality of an online simulation in the context of an online course or learning environment. These requirements were also developed with the following overarching tenets in mind: maximum reuse across multiple environments, interoperability, and durability.
To better understand the context and language used in the requirements, an overview of the PharamSim simulation characteristics is presented in the following paragraph.

As mapped against the Maier/Grobler Simulation Taxonomy, PharmaSim is defined by the following characteristics:

- Underlying Model
    - Real-word domain of business,
    - Special area of marketing,
    - Feedback oriented,
    - Deterministic model,
    - Discreet progress of time,
    - No influence from external data,
- Human-computer interface
    - User intervention occurring at discreet periods,
    - User input is decision-oriented,
- Functionality
    - Single person or group equals a user,
    - Black box – no transparency,
    - Time is advanced by users.

Purpose and Scope of the Survey:

This survey is an attempt to understand the strengths and weaknesses of SCORM 2004 in governing the development of each requirement. For the purposes of this survey it is necessary to assume that the set of requirements will not be met be developing one large multifunctional shareable content object (SCO) but instead will use multiple SCOs each most likely having a specific functionality so that the set of SCOs making up the content package will work together as a system. The following statements can be considered assumptions in fulfilling these requirements:

- Network accessibility is not a factor
- For reusability and durability, the requirements will be met by using SCO's that are based upon functionality or type instead of just instructional content. This would not be a "one big SCO" solution.
- A simulation engine will be embedded within a SCO and delivered as part of the course content package.
- The SCO's will not be required to communicate with an external system.
- A functional SCO is a SCO that provides a specific function or set of functions not necessarily intended to deliver conventional instructional content i.e. a role assignment function or a scenario choice function.
- All functional SCO's will be delivered as components of the course content package.

Instructions for Survey Completion

After reading the introduction and survey purpose and scope, please proceed to Demographics and choose or fill in the appropriate answers. Following Demographics, please proceed to read Requirement 1 carefully keeping in mind the simulation characteristics and assumptions from the Introduction and Purpose and Scope sections. Then choose the level of agreement you have concerning each of the six statements (a.-f.) as they pertain to the requirement. Repeat this process on the remaining seven requirements. There are eight requirements all together. Following the requirements are two open-ended items. Please take the time to give pertinent information for both items if you feel they are applicable. Your comments on these items are very valuable and would be much appreciated. Thank you for taking the time to respond to this survey.

Demographics

Aware of this survey through:

1. Direct email request
2. Responding from adlcommunity.net
3. Responding from other web community
4. Other ________________________________

Employment area (mark all that apply):

1. LMS developer
2. Learning content developer
3. Government
4. Government contractor
5. Standards or specifications entity (e.g. IEEE)
6. Academic Institution

Highest degree earned.

1. High School Diploma
2. Associates Degree
3. BA. or BS.
4. MA. or MS.
5. PhD.

6. Other ___________________________________
   If your highest degree is a BA/BS or higher, please give degree area – e.g. computer science or instructional design. ____

Years of experience as an IT developer.
1. No experience
2. Less than 1 year
3. 1 to 3 years
4. 4 to 7 years
5. 8 to 10 years
6. Over 10 years

Years of experience as an Instructional Designer (ID) or Instructional System Designer (ISD).
1. No experience
2. Less than 1 year
3. 1 to 3 years
4. 4 to 7 years
5. 8 to 10 years
6. Over 10 years

Years of experience developing SCORM 1 or 2.x-based courseware.
1. No experience
2. Less than 1 year
3. 1 to 3 years
4. 4 to 7 years
5. 8 to 10 years
6. Over 10 years

Years of experience developing SCORM 2004-based courseware.
1. No experience
2. Less than 1 year
3. 1 to 3 years
4. 4 to 7 years
5. 8 to 10 years
6. Over 10 years

Years of experience developing non-SCORM-based courseware.
1. No experience
2. Less than 1 year
3. 1 to 3 years
4. 4 to 7 years
5. 8 to 10 years
6. Over 10 years

Years of experience integrating online courseware with a Learning Management System (LMS).
1. No experience
2. Less than 1 year
3. 1 to 3 years

4. 4 to 7 years
5. 8 to 10 years
6. Over 10 years

Requirement 1: user selects their role and chooses a scenario within the simulation-based course.

Sub-level Components:

- The learner has logged on to the LMS and has chosen the simulation-based marketing course; user creates profile by choosing one of three roles and one of five scenarios.
- User role in the simulation will be progressively upgraded by default (i.e. assistant brand manager to brand manager) as determined by simulation performance, unless user disables default option.
- After making selections, user submits form.
- After submitting form, welcome page and case (scenario overview) are displayed and simulation play begins.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of one or more purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 2: user views case (scenario overview) and is welcomed to the course.

Sub-level Components:

- If new user, case is initially presented as a static story using text, graphics, and animations.
- If returning user, case access is optional.
- Case will be available to other entities outside this simulation who are seeking marketing domain knowledge.

Requirement 2 refinements and assumptions:

- The learner enters the course. If this is the first attempt by this learner in the course, then content called the "case" (hosted by a knowledge base as part of the course) is presented that provides an overview of the scenario. Subsequent reentry into the course resumes the previous attempt. The learner is allowed to view the "case" at will after they initially experience it.
- Scenario interacts with simulation behavior affecting such things as "budget."
- It is assumed that this requirement is fulfilled by at least one dedicated SCO

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of one or more purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 3: Data flows as input and output from an embedded simulation.

Sub-level Components:

- User will input “what if” data. This is data used for modeling decisions having no direct impact on the actual state of the simulation.
- User will input decision data. This is data that will impact the state of the simulation.
- Non-impact “What if” results data is available as output.
- Period final results data is available as output.
- It is assumed that this requirement is fulfilled by a dedicated SCO with an embedded simulation engine.
- The SCO will not be required to communicate with an external system.

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO’s are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of at least one purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO’s is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO’s.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 4: User views available reports contextual to the scenario, and simulation progression.

Sub-level Components:

- After user has created a profile and has viewed Case/welcome, reports become available and displayed built on data from the simulation.
- Availability of user to have specific reports displayed is directly tied to the state of the simulation.
- Specific reports may only be displayed after being "purchased" by the user.
- User report purchasing ability depends on the available budget supplied from the simulation.
- Purchasing a report debits budget data within the simulation.
- Reports will be viewable, printable, sortable, graphable, pivotable.
- All reports will be available to other entities outside this simulation who are seeking marketing domain knowledge.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of at least one purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 5: Budget feedback system.

Sub-level Components:

- Feedback will be provided to users during the simulation "what if" phase.
- Feedback will be immediate.
- Alerts will be provided when users exceed their available budget based upon budget data from the simulation.
- Feedback will be available and determined based upon reports visited and/or reports purchased.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of at least one purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 6: user views status.

Sub-level Components:

- User is able to persistently view simulation progress by period (1-10).
- Simulation progress data will be tracked by the LMS.
- User is able to persistently view summary status reports by period built from simulation state data.
- Summary status reports include cumulative periodic simulation data such as progressive performance and financial data.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of at least one purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 7: coaching system is available upon request.

Sub-level Components:

- After User has created profile and has viewed case/welcome, a coaching system is available to that user when modeling or making decisions within the simulation.
- Coaching system communicates with the simulation to monitor user input and simulation output.
- As requested by the user, coaching will provide (display) decision making information to the user pertaining to the type of decision and the potential outcome of that decision the user is about to make in the simulation.
- As requested by the user, coaching will provide (display) decision making feedback depending on the impact of the decision being made by the user when modeling a decision (simulation "what if"), based on an expert decision rubric.
- The coaching system will provide access tracking data back to the LMS.
- Coaching will be made available to other entities outside this course.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of at least one purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Requirement 8: user provides end of period reflection.

Sub-level Components:

- User must complete and submit a reflection write up using a pre-specified template before the simulation will be allowed to advance to the next period.
- Submittal data will be tracked by the LMS. Reflections will not be available to other users.
- Users will have access to a periodic rubric to gauge their thinking.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO.

Circle the number to the right of each statement that indicates your level of agreement.	1=strongly disagree 2=disagree 3=neutral 4=agree 5=strongly agree				
a. SCO's are very relevant to fulfilling this requirement.	1	2	3	4	5
b. The use of at least one purely functional SCO is very relevant to fulfilling this requirement.	1	2	3	4	5
c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.	1	2	3	4	5
d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.	1	2	3	4	5
e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.	1	2	3	4	5
f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different LMS specific functionality.	1	2	3	4	5

Open-ended item #1

Please list any current specifications or standards that could apply other than SCORM 2004 to fulfilling these requirements or describe those that would have to be developed.

Open-ended Item #2

If there is a technology that would fulfill these requirements better, please list and describe it.

Appendix D

ADL Cover Letter

Dear TWG,

Thank you to those that have provided survey input to Shane. However, Shane is looking for more results for his survey. If you have not and do have the opportunity to volunteer and participate in the survey, he would be gracious for your time and efforts.

Thanks
ADL

Patrick "Shane Gallagher" is a doctoral candidate at George Mason University and a senior knowledge engineer/senior instructional technologist with SAIC. Currently, he is performing research for his dissertation assessing SCORM 2004 for its affordances in facilitating the use of simulations as a pedagogical model with emphasis on interoperability and reusability.

At this time, he is looking for volunteers within the instructional technology field to participate by completing an online (and attached as a Word document) survey assessing SCORM 2004 functionality against a set of derived simulation requirements for relevancy in meeting the requirements. For your part, he is asking that you forward this email to an appropriate technical person (this could be yourself) or persons within your network or organization that could complete the survey. The survey can be accessed at https://www.questionpro.com/akira/TakeSurvey?id=713973 or by opening the attached Word document. If you prefer to complete the Word-based version, please email it to gallagherpat@saic.com upon completion.

The survey has three main sections: Demographics, Requirements, and Additional Information. There are eight demographic items and eight requirements each with six response items. At the end are two additional information open-ended items as well. All responses will be anonymous and respondents' privacy will be completely protected.

Your valued input will help understand the future of SCORM conformant simulation design and how SCORM and other learning object content models can more fully support advanced pedagogical models keeping in mind interoperability and reusability.

Shane's contact information is:
Patrick "Shane" Gallagher, Doctoral Candidate
College of Education and Human Development, George Mason University
10117 Schoolhouse Woods Ct.
Burke, VA 22015
Tel: 703-676-6391 Off or 703-589-6497 Cell
email: gallagherpat@saic.com or pgallag3@gmu.edu

Sincerely,
ADL

Appendix E

Sim SCORM 2004 Online Survey Screen Shot

52%

Simulation/SCORM 2004 Survey

DEMOGRAPHICS

Aware of this survey through:

- Direct email request
- Responding from adlcommunity.net
- Responding from other web community
- Other

Employment area (mark all that apply)

- LMS Developer
- Learning Content Developer
- Federal Government Contractor
- Government
- Standards or Specifications Entity (e.g. IEEE)
- Academic Institution
- Other

Highest degree earned.

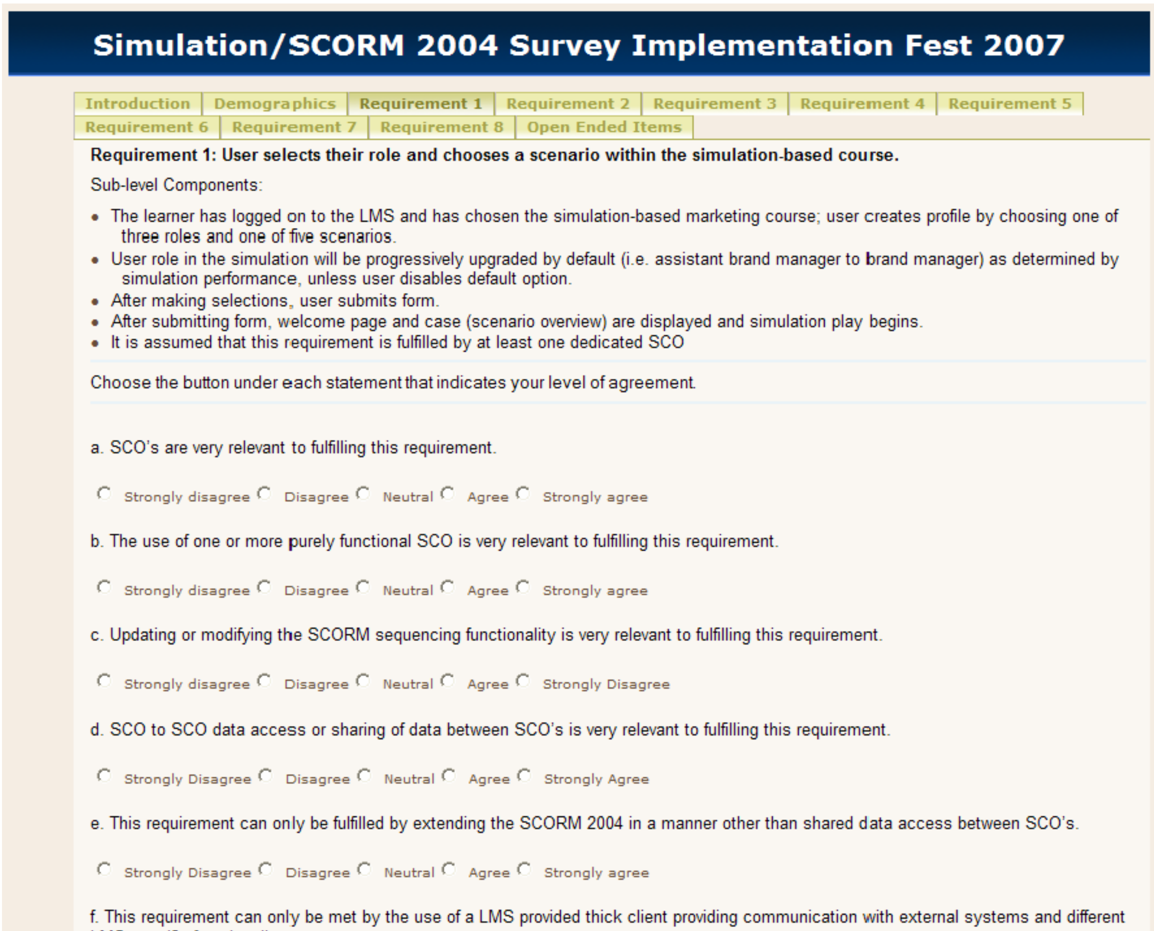
- High School Diploma
- Associates
- BA or BS
- MA, MS, or MEd
- PhD or EdD
- Other

If your highest degree is a BA/BS or higher, please give the degree area - e.g. computer science or instructional design.

Figure 28 Screen Shot of Online Survey

Appendix F

Sim SCORM 2004 Groove Survey


Simulation/SCORM 2004 Survey Implementation Fest 2007

Introduction | Demographics | Requirement 1 | Requirement 2 | Requirement 3 | Requirement 4 | Requirement 5 | Requirement 6 | Requirement 7 | Requirement 8 | Open Ended Items

Requirement 1: User selects their role and chooses a scenario within the simulation-based course.

Sub-level Components:

- The learner has logged on to the LMS and has chosen the simulation-based marketing course; user creates profile by choosing one of three roles and one of five scenarios.
- User role in the simulation will be progressively upgraded by default (i.e. assistant brand manager to brand manager) as determined by simulation performance, unless user disables default option.
- After making selections, user submits form.
- After submitting form, welcome page and case (scenario overview) are displayed and simulation play begins.
- It is assumed that this requirement is fulfilled by at least one dedicated SCO

Choose the button under each statement that indicates your level of agreement.

a. SCO's are very relevant to fulfilling this requirement.

Strongly disagree | Disagree | Neutral | Agree | Strongly agree

b. The use of one or more purely functional SCO is very relevant to fulfilling this requirement.

Strongly disagree | Disagree | Neutral | Agree | Strongly agree

c. Updating or modifying the SCORM sequencing functionality is very relevant to fulfilling this requirement.

Strongly disagree | Disagree | Neutral | Agree | Strongly Disagree

d. SCO to SCO data access or sharing of data between SCO's is very relevant to fulfilling this requirement.

Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree

e. This requirement can only be fulfilled by extending the SCORM 2004 in a manner other than shared data access between SCO's.

Strongly Disagree | Disagree | Neutral | Agree | Strongly agree

f. This requirement can only be met by the use of a LMS provided thick client providing communication with external systems and different

Figure 29 Screen Shot of Computer-based Survey

References

References

Adie, C., & Mark Ritchie. (2005). University Preferred Browsers for 2005–2006. Retrieved 6/4/07, 2007, from http://whitepapers.zdnet.com/thankyou.aspx?authId=O/nEWYeIV6Xyauz1amu5/7vwZ0T2XSksvYSDQUHYMjoP0Lzu70mQtHeC7mrGE7ep&&docid=166066&view=166066&load=1

ADL, & UK, P. L. (2007). SCORM Overview. Retrieved 15 September, 2007, from http://www.learninglab.org.uk/adl/scorm.asp?ses=

adlCommunity. (2007a). LETSI Working Area. Retrieved 17 September, 2007, from http://adlcommunity.net/course/view.php?id=18

adlCommunity. (2007b, 7/17/07). Main Section for adlCommunity. Retrieved 7/17/07, 2007, from http://adlcommunity.net/user/view.php?id=5&course=14

ADLNet. (2006). DoD Publications. Retrieved 05-03-06, 2006, from https://adlregistry.dtic.mil/2/index4.htm

Advanced-Distributed-Learning. (2004). *Sharable Content Object Reference Model (SCORM) Run-Time Environment (RTE) Version 1.3.1*. Retrieved. from http://www.adlnet.org.

Advanced Distributed Learning [ADL]. (2004a). *Sharable Content Object Reference Model (SCORM) 2004: Overview* (2nd ed.). Alexandria: ADL, United States Government.

Advanced Distributed Learning [ADL]. (2004b). *Sharable Content Object Reference Model (SCORM): Run-Time Environment (RTE) Version 1.3.1* (2nd ed.). Alexandria: ADL, United States Government.

Advanced Distributed Learning [ADL]. (2006a). *Sharable Content Object Reference Model (SCORM) 2004 3rd Edition: Overview* (3rd ed.). Alexandria: ADL, United States Government.

Advanced Distributed Learning [ADL]. (2006b). *Shareable Content Object Reference Model (SCORM) 2004 3rd Edition: Run-Time Environment Version 1.0* (3 ed.). Alexandria: ADL, United State Government.

Advanced Distributed Learning [ADL]. (2006c). *Shareable Content Object Reference Model (SCORM) 2004 3rd Edition: Sequencing and Navigation Version 1.0* (3 ed.). Alexandria: ADL, United State Government.

Advanced Distributed Learning [ADL]. (2006d). *Shareable Content Object Reference Model (SCORM) 2004 3rd Edition:Content Aggregation Model (CAM) Version 1.0* (3rd ed.). Alexandria: ADL, United States Government.

Advanced Distributed Learning [ADL]. (2006e). *Shareable Content Reference Model (SCORM) 2004 3rd Edition: Impact Summary* (3, Trans.). Alexandria: ADL, United States Government.

Advanced Distributed Learning Partnership Lab UK. (2007). SCORM Overview. Retrieved 15 September, 2007, from http://www.learninglab.org.uk/adl/scorm.asp?ses=

Aviation Industry CBT Committee [AICC]. (2004). CMI001-AICC/CMI Guidelines for Interoperabiliy Verson 4.0 (Publication. Retrieved 14 September, 2007, from Aviation Industry CBT Committee: http://www.aicc.org/docs/tech/cmi001v4.pdf

Aviation Industry CBT Committee [AICC]. (2005). AGR011-CBT Package Exchange Notification. Retrieved 14 September, 2007, from http://www.aicc.org/docs/AGRs/agr011v1.pdf

Aldrich, C. (2004). *Simulations and the future oflLearning: Innovative (and perhaps revolutionary) approach to e-learning*. San Francisco: Pfeiffer.

Aldrich, C. (2006). Beyond books. Unpublished Manuscript.

Alessi, S. (2000). Building versus using simulations. In J. M. Specotr & T. M. Anderson (Eds.), *Integrated and holistic perspectives on learning, instruction and technology* (pp. 175-196). Netherlands: Kluwer Academic Publishers.

Andrews, D., Nonnecke, B., & Preece, J. (2003). Conducting Research on the Internet: Online Survey Design, Development and Implementation Guidelines. *International Journal of Human-Computer Interaction, 16*, 185-210.

Baker, K. D. (2006). Learning Objects and Process Interoperability. *International Journal on E-Learning, 5*, 167-172.

Bannan-Ritland, B., Dabbagh, N., & Murphy, K. (2001). Learning object systems as constructivist learning environments: Related assumptions, theories, and applications. In D. Wiley (Ed.), *The instructional use of learning objects*. Bloomington: Agency for Instructional Technology : Association for Educational Communications & Technology.

Barritt, C. (2001). *Reusable learning object strategy v4.0*. San Francisco: Cisco Systems, Inc.

Barritt, C., & Alderman, F. L. (2004). *Creating a reusable learning objects strategy : leveraging information and learning in a knowledge economy*. San Francisco, CA: Pfeiffer.

Baruque, L. B., & Melo, R. N. (2004). Learning Theory and Instruction Design Using Learning Objects. *Journal of Educational Multimedia and Hypermedia, 13*, 343-370.

Blandin, B. (2003). *Are e-learning standards neutral?* (Academic Paper). Paris: CESIO.

Camp, J. S., DeBlois, P. B., & Committee, E. C. I. (2007). Top 10 2007 IT Issues. *EDUCAUSE Review*(May/June 2007), 12-32.

Christensen, E., Curbera, F., Meredith, G., & Weerawarana, S. (2001). Web Services Description Language (WSDL) 1.1. Retrieved 15 September, 2007, from http://www.w3.org/TR/wsdl

Clark, R. C. (1998). Recycling Knowledge with Learning Objects. *Training & Development* (October 1998), 60-61.

Cockburn, A. (2001). *Writing effective use cases*. Boston: Addison-Wesley.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research Methods in Education* (5th ed.). London: Routledge Falmer.

Conlan, O., Wade, V., Bruen, C., & Gargan, M. (2002). *Multi-model, Metadata Driven Approach to Adaptive Hypermedia Services for Personalized elearning*.

Culwin, F. (2004, December). *Beyond learning objects: Towards learning beans.* Paper presented at the Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference, Perth.

Defense Modeling and Simulation Office [DMSO]. (2006, 5-08-2006). Defense Modeling and Simulation Office (DMSO Website. Retrieved 6-9-06, 2006, from https://www.dmso.mil/public/

Dodds, P., & Fletcher, J. D. (2004). Opportunities for New "Smart" Learning Environments Enabled by Next-Generation Web Capabilities. *Journal of Educational Multimedia and Hypermedia, 13*, 391-404.

Doerksen, T. L. (2002). Content repurposing: Supporting models, methodology, and content development techniques. *MAI, 41*(05), 125.

Downes, S. (2001). Learning objects: resources for distance education worldwide. *International Review of Research in Open and Distance Learning* Retrieved 1, 2, from http://www.icaap.org/iuicode?149.2.1.2

Driscoll, M. P. (2000). *Psychology of learning for instruction* (2nd ed.). Boston: Allyn and Bacon.

Duncan, C. (2003a). Conceptions Of Learning Objects: Social And Educational Issues. *Journal of interactive media in education* (Special Issue on Reusing Online Resources).

Duncan, C. (2003b). Granularization. In A. Littlejohn (Ed.), *Reusing online resources : A sustainable approach to e-learning* (pp. 12-19). London ; Sterling, VA: Kogan Page.

Duval, E. (2004). Learning technology standardization: making sense of it all. *Computer Science and Information Systems, 1*(1), 33-43.

Duval, E., & Hodgins, W. (2003, 20-24 May 2003). *A LOM research agenda.* Paper presented at the WWW2003 Conference, Budapest, Hungary.

EduTools. (2007). ArchiveCMS: CMS Home. Retrieved August 11, 2007 from http://www.edutools.info/static.jsp?pj=8&page=HOME

European Computer Manufacturers Association [ECMA]. (2005). Standard ECMA-357. Retrieved 16 September, 2007, from http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-357.pdf

Fowler, F. J. (2002). *Survey Research Methods*. Thousand Oaks: Sage Publications.

Friesen, N. (2005). Interoperability and Learning Objects: An Overview of E-Learning Standardization [Electronic Version]. *Interdisciplinary Journal of Knowledge and Learning Objects*, *1*, from http://ijklo.org/Volume1/v1p023-031Friesen.pdf

Gallagher, P. S. (2002). Distributed learning: best practices in industry, academia, and governmental agencies. Paper written for SAIC in support of the US AF ADL Strategic Plan.

Gallagher, P. S. (2005, June). *Design for Knowledge Management.* Paper presented at the Innovations in E-Learning Symposium 2005, Fairfax.

Gilhooly, K. (2001). Making e-learning effective [Electronic Version]. *Computerworld*, *35*, 52-53. Retrieved August 5, 2007 from Research Library Core database. (Document ID: 75514405),

Google. (2006). Google Scholar SCORM search. Retrieved 05/03/2006, 2006, from http://scholar.google.com/scholar?q=SCORM&ie=UTF-8&oe=UTF-8&hl=en&btnG=Search

Government, U. S. (1998). Section 508. Retrieved 9 September, 2007, from http://www.section508.gov

Grimmitt, M. (2000). Pedagogies of religious education: Opening up a new field of research in RE. Retrieved 18 September, 2007, from http://www.studyoverseas.com/re/re.htm

Hall, B. (2002). Six steps to developing a successful e-learning initiative: excerpts from the e-learning guidebook. In A. Rossett (Ed.), *The ASTD E-Learning Handbook* (pp. 234-250). New York: McGraw-Hill.

Hall, B. (2007). LMS and LCMS Demystified. Retrieved 12 August, 2007, from http://www.brandon-hall.com/free_resources/lms_and_lcms.shtml

Harper, B., Bennett, S., Lukasiak, J., & Lickyer, L. (2005). Learning designs to support educationally effective e-learning using learning objects. Wollongong: Research Centre for Interactive Learning Environments, Telecommunications and Information Technology Research Institute, University of Wollongong.

Hay, D. C. (2003). *Requirements analysis: from business views to architecture*. Upper Saddle River: Prentice Hall PTR.

Haynes, J., Marshall, S., Manikinda, V., & Maloor, P. (2004, December). *Enriching ADL through integration of HLA Simulation with SCORM Instruction with SITA (Simulation-based Intelligent Training and Assessment)*. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2004.

Herz, J. C. (1997). *Joystick nation : How videogames ate our quarters, won our hearts, and rewired our minds*. Boston: Little, Brown, and Co.

Hiemstra, R. (2006). Moving from pedagogy to andragogy. Adapted and updated from (1990) *Individualizing instruction. San Francisco: Jossey-Bass* Retrieved 7 September, 2007, from http://www-distance.syr.edu/andraggy.html

Hodgins, H. W. (2000). Into the Future: A Vision Paper (pp. 60): Commission on Technology & Adult Learning: A Joint Project of the American Society for Training & Development (ASTD) and the National Governors' Association (NGA).

Horn, R. E. (1998). *Instructional Development: State of the Art*. Englewood Cliffs, NJ: Educational Technology Publications.

Hurwitz, J., Bloor, R., Baroudi, C., & Kaufman, M. (2007). *Service oriented architecture for dummies*. Hoboken, NJ: Wiley Publishing.

Hutchinson, S. R. (2004). Survey Research. In K. deMarrais & S. D. Lapan (Eds.), *Foundations for research: Methods of inquiry in education and the social sciences* (pp. 283-301). Mahwah, NJ: Lawrence Erlbaum Associates.

IMS Global Learning Consortium, I. (2003a). IMS Simple Sequencing Specification. Retrieved 14 August, 2007, from http://www.imsglobal.org/simplesequencing/index.html

IMS Global Learning Consortium, I. (2003b). Learning Design Specification v1.0. Retrieved 13 September, 2007, from http://www.imsglobal.org/learningdesign/index.html

IMS Global Learning Consortium, I. (2005). IMS Content Packaging Overview. Retrieved 15 August, 2007, from http://www.imsglobal.org/content/packaging/cpv1p2pd/imscp_oviewv1p2pd.html

IMS Global Learning Consortium, I. (2006). IMS Shareable State Persistence Information Model. Retrieved 6/20/07, 2007, from http://www.imsglobal.org/ssp/

Institute of Electrical and Electronic Engineers Learning Technology Standards Committee [IEEE LTSC]. (2002). IEEE Standard 1484.12.1 Standard for Learning Object Metadata Retrieved 6/2/2007, 2007

Institute of Electrical and Electronic Engineers Learning Technology Standards Committee [IEEE LTSC]. (2005, May 1, 2005). IEEE Standard 1484.12.1 Standard for Learning Object Metadata. Retrieved December 28, 2005, 2005, from http://ieeeltsc.org/wg12LOM/lomDescription

Institute of Electrical and Electronics Engineers [IEEE]. (2000). IEEE 1516-2000 Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) — Framework and Rules. Retrieved 21 October, 2007, from http://ieeexplore.ieee.org/iel5/7179/19334/00893287.pdf?tp=&isnumber=19334&arnumber=893287

Institute of Electrical and Electronics Engineers [IEEE]. (2004, 3 September 2--7). IEEE Std. 1484.11.2 - 2003 - IEEE Standard for Learning Technology - ECMAScript application programming interface for content to runtime services communication. Retrieved 3 September, 2007, from http://ieeexplore.ieee.org/servlet/opac?punumber=8972

Institute of Electrical and Electronics Engineers [IEEE]. (2005). IEEE Std 1484.11.1 - 2004 IEEE Standard for Learning Technology - Data Model for Content to Learning Management System Communication [Electronic Version], from http://ieeexplore.ieee.org/servlet/opac?punumber=9661

International Standards Organization [ISO]. (2007a). International Standardization and Education. Retrieved 15 September, 2007, from http://www.iso.org/iso/about/international_standardization_and_education.htm

International Standards Organization [ISO]. (2007b). Why Standards Matter. Retrieved 15 September, 2007, from http://www.iso.org/iso/about/discover-iso_meet-iso/discover-iso_why-standards-matter.htm

Interpretive. (2006). PharmaSim, PharmaSim Management Simulation. Retrieved 6-9-2006, 2006, from http://www.interpretive.com/pharmasim/

Interpretive Software, I. (2006). *PharmaSim: The marketing management simulation user's guide*. Philadelphia: Drexel University.

Ip, A., & Canale, R. (2003). *Supporting collaborative learning activities with SCORM*. Paper presented at the Edcuause in Australasia.

Jaeger, R. M. (1993). *Statistics: A spectator sport* (2nd ed.). Newbury Park: Sage Publications.

James, S. W., Kinnear, T. C., & Deighan, M. (1999). *PharmaSim: A brand management simulation administrator's guide v 2.0*. Charlottesville: Interpretive Simulations.

Jesukiewicz, P., & Panar, A. (2006, 18 January, 2006). Content Object Repository and Registration Architecture CORDRA and ADL Registry. Retrieved 10 September, 2007, from http://www.google.com/url?sa=t&ct=res&cd=3&url=http%3A%2F%2Fwww.adlnet.gov%2Fdownloads%2FAuthNotReqd.aspx%3FFileName%3DIP2D0118T1000TR1.ppt%26ID%3D54&ei=pkHlRqLrAqWYevGDlZIK&usg=AFQjCNH87m14eogVETISpXlZs7QR23IqnQ&sig2=splqaWNxdVYZBGcy8rBt_A

Joint Advanced Distributing Co-lab [JADL]. (2007). 2007 Research Activities: Learner Assessment Model for Tactical Combat Casualty Care (TC3). Retrieved 15 September, 2007, from http://www.jointadlcolab.org/research/2007/index.aspx

Jonassen, D., & Churchill, D. (2004). Is there a learning orientation in learning objects? *International Journal on E-Learning, 3*(2), 32-41.

Katz, H., Worsham, S., Coleman, S., Murawski, M., & Robbins, C. (2004). *Reusable Learning Object Model Design and Implementation: Lessons Learned.* Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2004, (pp. 2483-2490). Chesapeake, VA: AACE.

Kelly, A. (2004). Design research in education: Yes, but is it methodological? *Journal of the Learning Sciences, 13*(1), 115-128.

Kilby, T. (2004, 2004). Overview of e-learning standards. Retrieved 6/3/07, 2007, from http://www.webbasedtraining.com/primer_standards.aspx

Knowles, M. S. (1984). *Andragogy in action*. San Francisco: Jossey-Bass.

Koper, R. (2003). Combining reusable learning resources and services with pedagogical purposeful units of learning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to e-learning* (pp. 46-59). London: Kogan Page.

Koper, R., & Tattersall, C. (2005). Preface to learning design: A handbook on modeling and delivering networked education and training [Electronic Version]. *Journal of Interactive Media in Education*, *18*, 1-7. Retrieved 13 September 2007, from http://www.jime-open.ac.uk/2005/18

Koppi, T., Bogle, L., & Lavitt, N. (2004). Institutional use of learning objects: Lessons learned and future directions. *Journal of Educational Multimedia and Hypermedia, 13*, 449-463.

Korea Education & Research Information Service [KERIS]. (2003). *Adapting Education to the Information Age*. Retrieved. from http://www.keris.or.kr.

Kraan, W., & Wilson, S. (2002). Dan Rehak: "SCORM is not for everyone." Retrieved 4/1/06, 2006, from http://www.cetis.ac.uk/content/20021002000737

L'Allier, J. J. (1997, 12/11/2005). Frame of Reference: NETg's Map to its Products, their Structures and core beliefs. Retrieved 12/11/2005, 2005, from http://web.archive.org/web/20040411161213/www.netg.com/research/whitepapers/frameref.asp

Learning Systems Architecture Lab [LSAL]. (2004). *SCORM Best practices guide for content developers* (2004 ed.). Pittsburgh: Carnegie Mellon University.

Lukasiak, J., Agostinho, S., Burnett, I., Drury, G., Goodes, J., Bennett, S., et al. (2004). A framework for the flexible content packaging of learning objects and learning designs. *Journal of Educational Multimedia and Hypermedia, 13*, 465-481.

Maier, F. H., & Grobler, A. (2000). What are we talking about?—A taxonomy of computer simulations to support learning. *System Dynamics Review, 16*, 135-148.

Maurer, T. J., & Andrews, K. D. (2000). Traditional, likert, and simplified measures of self-efficacy. *Educational and Psychological Measurement, 60*, 965-973.

Maxwell, J. A. (1996). *Qualitative research design*. Thousand Oaks: Sage Publications.

McCormick, R. (September 2003). *Keeping the pedagogy out of learning objects*. Paper presented at the Designing Virtual Learning Material Symposium at EARLI 10th Biennial Conference: Improving Learning, Fostering the Will to Learn.

Meer, E. V. (2003). PLATO: From computer-based education to corporate social responsibility [Electronic Version]. *Iterations: An Interdisciplinary Journal of Software History*. Retrieved 5 August, 2007, from http://www.cbi.umn.edu/iterations/vanmeer.html

Menaker, E., Coleman, S., Collins, J., & Murawski, M. (2006, December). *Harnessing experiential learning theory to achieve warfighting excellence*. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2006.

Merrill, D. (2000). Instructional transaction theory (ITT): instructional design based on knowledge objects. In C. Reigeluth (Ed.), *Instructional-Design Theories and Models: A new paradigm of instructional theory*. Mahwah, NJ: Lawrence Erlbaum Associates.

Mertens, D. M. (1998). *Research methods in education and psychology: Integrating diversity with quantitative & qualitative approaches*. Thousand Oaks: Sage.

Metros, S. E., & Bennett, K. (2002). Learning Objects in Higher Education. *Educause Center for Applied Research Research Bulletin,* 2002 (19), 10.

Miller, P. (2000). "Interoperability. What is it and Why should I want it?" [Electronic Version]. *Ariadne* Retrieved January 1, 2006, from http://www.ariadne.ac.uk/issue24/interoperability/intro.html

Miller., M., & Childs, R. (2004, June). *Practical modeling & simulation for online courses: Proposal for A low level architecture.* Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications (EDMEDIA) 2004, Lugano, Switzerland.

Norton, P. (2003, March). *COPLS: An alternative to traditional online course management tools.* Paper presented at the Society for Information Technology and Teacher Education International Conference 2003, Albuquerque, New Mexico, USA.

Norton, P., & Sprague, D. (2001). *Technology for teaching*. Boston: Allyn and Bacon.

Oakes, K. (2002). E-Learning [Electronic Version]. *T + D*, *56*, 73-75. Retrieved March 2002 from Banking Information Source database. (Document ID: 111468179),

Oliver, R., & McLoughlin, C. (2003). Pedagogical designs for scalable and sustainable online learning. In A. Littlejohn (Ed.), *Reusing online resources: a sustainable approach to e-learning*. London: Kogan Page.

Olivier, B., & Liber, O. (2003). Learning content interoperability standards. In A. Littlejohn (Ed.), *Reusing Online resources: a sustainable approach to e-learning*. London: Kogan Page.

Organization for the Advancement of Structured Information Standards Darwin Information Typing Architecture (DITA) TC [OASIS DITA]. (2005). OASIA Darwin Information Typing Architecture (DITA) Architectural Specification v1.0. Retrieved 2 October, 2007, from http://docs.oasis-open.org/dita/v1.0/dita-v1.0-spec-os-ArchitecturalSpecification.pdf

Organization for the Advancement of Structured Information Standards UDDI Specification Technical Committee [OASIS USPTC]. (2007). OASIS Standards: Universal Description, Discovery and Integration (UDDI) v3.0.2. Retrieved 15 September, 2007, from http://www.oasis-open.org/specs/index.php#uddiv3.0.2

Ostyn, C. (2006). XML and the SCORM CMI data model. Retrieved 12 August, 2007, from http://www.ostyn.com/standards/docs/xml1484-11-3.htm

Ostyn, C. (2007). *In the Eye of the SCORM: An introduction to SCORM 2004 for Content Developers*. Retrieved 13 August 2007, from http://www.ostyn.com/standards/docs/Eye_Of_The_SCORM_draft.pdf

Pasini, N., & Rehak, D. R. (2003). A process model for applying standards in content development 2006, from http://www.lsal.cmu.edu/

Phelps, S. (2004). JKDDC interim distribution capability data model assessment v.1. Unpublished Draft. SAIC.

Pitkanen, S. H., & Silander, P. (2004, August- September). *Criteria for pedagogical reusability of learning objects enabling adaptation and individualised learning processes.* Paper presented at the Advanced Learning Technologies 2004. Proceedings IEEE International Conference.

Plateau Systems, L. (2007). Learning Management System. Retrieved 5 August, 2007, from http://www.plateau.com/prod/learning-management-systems.htm

Polsani, P. R. (2003). Use and abuse of reusable learning objects. *Journal of Digital Information, 3*(4) Article No. 164, 2003-02-19 1.

.

Prensky, M. (2001). *Digital game-based learning*. New York: McGraw-Hill.

Refsnes, H., Refsnes, S., & Refsnes, J. E. (2007). SOAP Tutorial. *W3Schools* Retrieved 22 October, 2007, from http://www.w3schools.com/soap/default.asp

Rehak, D. R. (2006, 6-07-06). *The 5 R's of Workforce Training: Enabling Technologies for Scalable Solutions.* Paper presented at the Innovations in E-Learning Symposium 2006, Fairfax, VA.

Rehak, D. R., & Mason, R. (2003). Keeping the learning in learning objects. In A. Littlejohn (Ed.), *Reusing online resources : A sustainable approach to e-learning*. London ; Sterling, VA: Kogan Page.

Reigeluth, C. M. (1983). *Instructional-design theories and models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Richey, R. C., Klein, J. D., & Nelson, W. A. (2004). Developmental research: Studies of instructional design and development. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology* (2nd ed., pp. 1099-1130). Mahwah, NJ: Lawrence Erlbaum.

Robson, C. (1993). *Real world research : a resource for social scientists and practitioner-researchers*. Oxford, UK ; Cambridge, MA: Blackwell.

Robson, C. (2002). *Real world research* (2nd ed.). Malden, MA: Blackwell.

Rosson, M. B., Carroll, J. M., & Bellamy, R. K. E. (1990, October). *Smalltalk scaffolding:A case study of minimalist instruction.* Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems: Empowering people CHI '90, Seattle.

Rothwell, W. J., & Kazanas, H. C. (1998). *Mastering the instructional design process : A systematic approach* (2nd ed.). San Francisco: Jossey-Bass.

Sallaberry, C., Nodenot, T., Laforcade, P., & Marquesuzaa, C. (2005). *Model driven development of cooperative problem-based learning situations implementing tools for teachers and learners from pedagogical models*. Paper presented at the HICSS '05: Proceedings of the 38th Annual Hawaii International Conference on System Sciences. Retrieved 18 September, 2007, from http://mutex.gmu.edu:2101/search/srchabstract.jsp?arnumber=1385314&isnumber=30166&punumber=9518&k2dockey=1385314@ieeecnfs&query=%28sallaberry%2C+c.+++nodenot%2C+t.+++laforcade%2C+p.+++marquesuzaa%2C+c.+++%29+%3Cin%3E+metadata&pos=0

Saunders, P. M. (1997). Experiential learning, cases, and simulations in business communication. *Business Communication Quarterly, 60*, 97-114.

SearchSMB.com. (2006). SMB definitions: Gap analysis. Retrieved 05-17-2006, 2006, from http://searchsmb.techtarget.com/sDefinition/0,290660,sid44_gci831294,00.html

Seitz, R. B. (2004). *Early teen girls as user-designers: A case study of the application of the user-design and design-within approaches and implications for the instructional design (ID) process.* Unpublished Doctoral Dissertation, George Mason University, Farifax, VA.

Shank, P. (2001). Out with the old: Is it time to rethink instructional design? *Online Learning*, 1-4. Retrieved November 30, 2005, from http://www.trainingmag.com/training/search/search_results.jsp

Sierra, J. L., Fernandez-Valmayor, A., Guinea, M., Hernanz, H., & Navarro, A. (2005, July). *Building repositories of learning objects in specialized domains: the Chasqui approach.* Paper presented at the Advanced Learning Technologies. 2005. ICALT 2005. Fifth IEEE International Conference

Sims, R. C. H. (1997). Interactive learning as an "emerging" technology: A reassessment of interactive and instructional design strategies. *Australian Journal of Educational Technology, 13*, 68-84.

Sosteric, M., & Hesemeier, S. (2002). When is a learning object not an object: A first step towards a theory of learning objects [Electronic Version]. *International Review of*

Research in Open and Distance Learning, *3*, 1-16. Retrieved 11 September, 2007, from http://www.irrodl.org/index.php/irrodl/article/view/106/557

Strijker, A. A. (2004). Reuse of learning objects in context: Human and technical aspects. *DAI, 65*(04C), The Netherlands: University of Twente.

Su, S., & Lee, G. (2003). *A web-service-based, dynamic and collaborative learning management system.* Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2003, Phoenix, Arizona, USA.

Sulistio, A., Yeo, C. S., & Buyya, R. (2004). A taxomony of computer-based simulations and its mapping to parallel and distributed systems simulation tools. *Software-Practice and Experience, 34*, 653-673.

Sutcliffe, A. (2002). *The domain theory : Patterns for knowledge and software reuse*. Mahwah, NJ: L. Erlbaum Associates.

Swinski, J., & Williams, M. (2004, December). *Web browser-based architecture for reusable simulation objects (rsos) in PC simulations*. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2004.

Szabo, M. (2002). *CMI Theory and practice: historical roots of learning management systems.* Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2002, Montreal, Canada.

Thomas, E. (2005). *Service-Oriented Architecture: Concepts, Technology, and Design*. Indianapolis, IN: Prentice-Hall PTR.

Tracey, J. R., Rugh, D. E., & Starkey, W. S. (1965). Sequential thematic organization of publications (STOP). *Journal of Computer Documentation, 23*(3), 4-68.

Travers, G. (2007, August). *Supporting team training in the joint ADL co-Lab IPA.* Paper presented at the Implementation Fest 2007, Orlando.

Treviranus, J., & Brewer, J. (2003). Developing and Reusing Accessible Content and Applications. In A. Littlejohn (Ed.), *reusing online resources: A sustainable approach to e-learning* (pp. 119-128). London: Kogan Page.

Verbert, K., Dragan, G., Jovanovi, J., & Duval, E. (2005, May). *Ontology-based learning content repurposing*. Paper presented at the Special interest tracks and posters of the 14th international conference on World Wide Web, Chiba, Japan.

Verbert, K., & Duval, E. (2004). *Towards a global architecture for learning objects: a comparative analysis of learning object content models.* Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004, Lugano, Switzerland.

Verbert, K., Klerkx, J., Meire, M., Najjar, J., & Duval, E. (2004). *Towards a global component architecture for learning objects: an ontology based approach*. R. Meersman (Ed.), *OTM Workshops 2004, LNCS 3292*, (pp.713–722) Berlin: Springer-Verlag.

Visscher-Voerman, I., Gustafson, K., & Plomp, T. (1999). Educational design and development: an overview of paradigms. In J. J. H. v. d. Akker, R. M. Branch, K. Gustafson, N. Nieveen, & J. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 15-28). Dordrecht ; Boston: Kluwer Academic Publishers.

Watson, J., & Ahmed, P. K. (2004). Learning in the Age of Global Information Technology [Electronic Version]. *Campus-Wide Information Systems*, *21*, 4-21. Retrieved 1/3/2006,

Watson, W. R., & Watson, S. L. (2007). An argument for clarity: what are learning management systems, what are they not, and what should they become? *TechTrends, 51*(2), 28-34.

Wikipedia-contributors. (2005, January 1, 2006). Application programming interface. from http://en.wikipedia.org/w/index.php?title=Application_programming_interface&oldid=32973825

Wikipedia-contributors. (2006, 1 January 2006). Learning management system. Retrieved 1 January 2006, 2006, from http://en.wikipedia.org/w/index.php?title=Learning_management_system&oldid=33438917

Wikipedia. (2007, 15 September, 2007). Coupling (computer science). *Wikipedia, The Free Encyclopedia*, from http://en.wikipedia.org/w/index.php?title=Coupling_%28computer_science%29&oldid=156286638

Wiley, D. A. (2001). Learning objects need instructional design theory. In A. Rossett (Ed.), *The ASTD e-learning handbook* (pp. 115-126). New York: McGraw-Hill.

Wiley, D. A. (2002). *The instructional use of learning objects* (1st ed.). Bloomington, Ind.: Agency for Instructional Technology : Association for Educational Communications & Technology.

Wiley, D. A. (2006, June). *The role of openness in the future of education.* Paper presented at the Innovations in E-Learning Symposium 2006, Fairfax, VA.

World Wide Web Consortium [W3C]. (2005). Document Object Model (DOM). Retrieved 16 September, 2007, from http://www.w3.org/DOM/

World Wide Web Consortium [W3C]. (2007a). Semantic Seb. Retrieved 16 September, 2007, from http://www.w3.org/2001/sw/

World Wide Web Consortium [W3C]. (2007b). SOAP Version 1.2 Part 1: Messaging Framework (Second Edition). Retrieved 22 October, 2007, from http://www.w3.org/TR/soap12-part1/#intro

World Wide Web Consortium [W3C]. (2007c). World Wide Web Consortium Home Page. Retrieved 6/4/07, 2007, from http://www.w3.org/

Young-Sik, J., & Seong-Hun, A. (2005, July). *Development of cooperative learning object based on SCORM.* Paper presented at the Fifth IEEE International Conference on Advanced Learning Technologies, Kaohsiung, Taiwan.

Zouaq, A., Nkambou, R., & Frasson, C. (2007). An integrated approach for automatic aggregation of learning knowledge objects [Electronic Version]. *Interdisciplinary Journal of Knowledge and Learning Objects*, *3*. Retrieved 16 September, 2007, from http://ijklo.org/Volume3/IJKLOv3p135-162Zouaq.pdf

Curriculum Vitae

Patrick Shane Gallagher was born and raised in New Mexico where he graduated from Kirtland Central High School in 1978. Following high school, Shane completed a Bachelor of Music Education from Morehead State University in 1985. He then completed a Master of Arts degree in Education (Integrating Technology into Schools) from the University of New Mexico in 1998. Shane also holds certificates from the University of Arizona in Computers in Music and Programming the MIDI (musical instrument digital interface).

Currently Shane is a Chief Knowledge Engineer/Instructional Technologist, and project manager in the Analysis, Strategies, Simulations, Engineering, and Training Business Unit of Science Applications International Corporation (SAIC). Mr. Gallagher has been the technical lead on various large knowledge management and e-learning programs and has designed and developed learning and knowledge architectures and systems for various organizations within the DoD. Shane is currently the technical lead for knowledge management support for the Chief Knowledge Officer of the NASA Johnson Space Center. He was the task lead over the analysis team for the Joint Knowledge Development and Distribution Capability (JKDDC) and was also the principle subject matter expert in developing the strategic plan for Advanced Distributed Learning for the Air Force. Shane oversaw the development of the DON Financial Execution Courses the first of which was chosen as the outstanding e-learning product at the national and chapter levels of the American Society of Military Comptrollers. He was the architect of the AF Preliminary Planning (PP) portal supporting research, knowledge management, training, and performance support and was the principle designer of the PP research methodologies and technologies used with virtual worldwide collaboration teams.

Shane's professional interests include learning object content models and the convergence of e-learning and knowledge management. While at SAIC, he has led an internal research and development project in the design and development of new content object models to support learning and knowledge provisioning within smart enterprise systems and is participating in the formation of the Learning Education Training Standards Interoperability (LETSI) as a global steward for SCORM, its future developments, and the identification and development of other global reference models. Shane represented SAIC in the Knowledge Management and Strategic Distance Learning Syndicates for the Joint Management Office for JKDDC with all of his recommendations accepted by the panels overseeing the initiatives. He has also been instrumental in strategizing and evolving learning technology concepts into implementable processes, tools, and procedures. He is active in business and proposal development and has successfully supplied thought leadership, technical expertise, and guidance to many proposal efforts involving e-learning development, the convergence of e-learning, knowledge management, and current research and trends.

Shane has also taught in the K-12 public and private, community college, and higher education levels since 1983. While in the K-12 area, he has led departments and participated on the technology committees at the district and state levels. He designed and taught courses on sound technology and computers in the musical classroom, and music education courses at the undergraduate level and was a district and state-wide in-service presenter for several years. Shane has also taught educational technology classes and education seminars at the graduate level for George Mason University.

Teaching Experience

George Mason University (1999-2001)

EDIT 504 - Introduction to Educational Technology. Three credit hour course examines the uses of and issues surrounding educational technology, focusing on computer related technologies and their application to educational tasks.

EDIT 564: Teaching with TV/Video. One credit hour course designed to assist students in exploring and developing expertise with social, cognitive, and learning implications of film, video, and television as well as engages students in the process of planning, storyboarding, and filming with video. Ways in which teachers can teach about and teach with television and video explored.

EDIT 566: Teaching with Multimedia/Hypermedia. Two credit hour course designed to assist students in exploring and developing expertise with a variety of hypertext/hypermedia and multimedia tools. Emphasis placed on students' ability to use hypermedia/multimedia tools and to then teach others to use these tools. Ways in which the integration of hypermedia /multimedia tools in the K-12 curriculum can support learning stressed.

EDIT 567: Teaching with Desktop Publishing. Two credit hour course designed to assist students in exploring and developing expertise with a variety of publishing tools to include word processors, desktop publishers, and idea processors. Emphasis was placed on using these tools to communicate. Design and layout principles, the appropriate use of images to facilitate communication, and the ways in which K-12 teachers can design opportunities for students to learn these concepts.

EDIT 574: Networking Tools for Instructional Systems Designers. Designed and implemented course to teach the basic knowledge of current networking and telecommunications devices used to enhance the instructional design process. The course covered local area networks, telecommunications, and teleconferencing and distance education technologies. The course is structured around exposure to the hardware devices available for accessing, managing, and publishing instructional materials on-line, specifically for the design of computer-based instruction.

EDCI 716: Principles of Integration. Three credit hour course designed to engage students in a continued consideration of curriculum design strategies appropriate for the integration of technology. The course included examples of curriculum design strategies, readings, discussions, and design of lessons or units appropriate to students' various contexts and contents. The second course in the sequence builds on previous student learning and focuses on technology's role in problem-based learning, problem-centered curriculum design, authentic instruction, and rationales and processes for implementing authentic assessment strategies.

EDIT 797: Web-based Learning. Three credit hour course is designed to assist students in exploring and developing expertise with the various aspects of web-based learning and modeling the ways in which these tools can be integrated into the teaching/learning process. Synchronous and asynchronous discussions, on-line resources, and web-based projects utilized in order to help students develop a working knowledge of web-based technologies.

EDIT 895: Emerging Issues in Educational Technology – Knowledge Management and Education (designed and co-taught). This is a seminar course designed and taught as a doctoral capstone course and occurring every other year with emphasis on new and emerging issues in the field of educational technology.

Kansas State University (1998)

Videoconference Faculty Member, Classroom Technology Graduate Program Workshop, Department of Secondary Education.

San Juan College (1982-1998)

Courses developed and taught: Computer Applications in Music, Sound Technology and Music for Elementary Teachers. Courses taught (only): Introduction to Music.

Navajo Preparatory School (1995-1998)

Instructor of multimedia technologies, technology committee chair, music instructor, assistant network administrator and co-designer. Designed and implemented multimedia classes, choral director and band director and taught one guitar class. Designed and managed the technology portion of the Navajo Language CD project and as Director of the recording studio, wrote and submitted NEH grant on gathering and maintaining a digital library of Navajo oral histories.

Central Consolidated School District (1986-1993)

Choral director, fine arts department chair, school technology committee member at Kirtland Central High School and Kirtland Middle School. Taught five choral classes and one guitar/theory class.

Selected Professional Experience

NASA JSC Knowledge Management Support, present, SAIC – Technical Lead. Activities included research design, implementation, and analysis expertise utilization for a quantitative KM maturity assessment of the Johnson Space Center practices and infrastructure. Also designed and oversaw KM assessment of the center-wide web architecture, library services, and lessons learned infrastructure and practices leading to the development of a roadmap for the implementation of a knowledge architecture and enterprise architecture in support of KM.

IR&D Smart Enterprise Systems Knowledge Object Content Model Development, 2005-2007, SAIC – Technical lead for SAIC internal research and development project assessing and developing more effective content models for knowledge objects to support the knowledge provisioning concept.

JKDDC Joint Management Office, 2004 – 2006, SAIC – Task Lead over the Analysis Task for the Joint Knowledge Development and Distribution Capability (JKDDC) Project. JKDDC was a $65 million project creating knowledge objects and learning objects for use by the joint warfighter. As the major tasks lead and the lead knowledge engineer, Shane oversaw and provided thought leadership for all knowledge management development efforts and tasks associated with the project. Tasks included the development of analysis processes, domain models, and object models being developed in support of JKDDC including the development of the of multiple taxonomies that encompassed essential concepts and characteristics of military science, including the joint military knowledge domain, the combatant command functional codes, the joint publications hierarchy, and the universal joint task lists. Additional tasks involved the creation and refinement of ontologies that identify the relationships between topics in the taxonomy. Oversaw sub-teams in requirements identification and analysis; knowledge harvesting and knowledge object development; learning object development; and knowledge management.

Air Force/DPMS Competitive Sourcing Support, 2003 - 2004, SAIC – AF/DPMS supported several MAJCOMs and bases in performing preliminary planning initiatives as required by the newest Circular A-76. This support included not only extensive data collection and analysis but integrating technology, knowledge management and performance support in the processes. As the project manager/technical lead in the area of technology, KM and performance support, Mr. Gallagher directly interfaced with the clients, gathered customer requirements, proposed new methodologies and technologies, and integrated collaborative processes and technology. He also facilitated a centralized and de-centralized approach to data collection, analysis and collaboration for virtual teams. Mr. Gallagher led the prototyping of the Competitive Sourcing portal, Groove integration and the development and evaluation of a new and innovative course in managing preliminary planning. Mr. Gallagher led the development of the Beta V1.0 Competitive Sourcing portal development, oversaw all of the technology to support virtual teaming and guided the development of various performance support and knowledge management capabilities.

Navy Funds Financial Courses Development, 2002 – 2004, SAIC – The Department of the Navy Office of the Assistant of the Navy Financial Management and Comptroller's Office had the need for several online course to be development in the financial arena. The courses included the Funds Usage Documents (FUD) course, Principles of Navy Budgeting, and Fiscal Law. As the program manager, Mr. Gallagher cultivated a strong relationship with the client, managed the program including proposal development, risk mitigation and business decisions, and managed a matrixed team of instructional designers, graphic designers and web programmers to complete the projects. Due to expanded requirements of the first course, the client extended the period of performance as the new requirements were incorporated. The end result was a product winning chapter and national awards and showcased throughout the DoD financial community.

Army Contractual Incentives Course Development, 2001 – 2003, SAIC – Contractual incentives as part of performance based contracting became an integral part of contracting. The Army acquisition community felt the need to attempt to train their contracting professionals in the understanding of what incentives were and how they were structured within a contract. SAIC was contracted to develop an innovative course the help those professionals think beyond their normal contracting paradigm and begin to think about contracting using incentives. This was a blended course relying on a project-based instructional design. Mr. Gallagher as the technical lead and project manager, led the design team through an extensive needs analysis, content analysis, design, development, implementation and evaluation of the course.

Air Force/DPLT, 2003, SAIC – The Air Force was mandated to implement Advanced Distributed Learning (ADL) throughout, and, in so doing needed to develop a strategic plan for implementing ADL. SAIC was contracted to support AF/DPLT in developing its strategic plan for ADL. Mr. Gallagher as the subject matter expert for this project led the development of the as-is assessment of the force, developed the research of existing best practices in distributed learning throughout industry and academia and facilitated focus groups and presentations. He also conducted interviews across various departments of the AF including the Academic Co-lab for the development and implementation of SCORM.

OSD (DAU) Contractual Incentives Distance Learning Module, 2001 – 2002, SAIC – With the need for more contracting professionals to understand how to think about contractual incentives, OSD contracted SAIC to develop a DAU distance learning module to help professionals think through the process of applying incentives. As the technical lead, Mr. Gallagher developed an innovative distance education model framed in the theory of lifelong learning including collaborative/cooperative learning, automated cohorts and alternative assessments for implementation. In applying the model, the module was designed around a simulation involving a transportation scenario and required the learners to think and react in a realistic way. Mr. Gallagher led a matrixed team of instructional designers, web developers and graphic artists to bring the concept to reality. The client was well pleased and the course is currently used as an exemplarily module.

mindsim.com Development,(1999 - 2000), MindSim Corporation – As the project lead, Mr. Gallagher used the ISD process for analysis and design and the development of instructional systems and instructional materials for web-based delivery. Mr. Gallagher programmed and debugged applications. He also performed an in-depth analysis of PharmaSim, a computer-based marketing simulation and analyzed the simulation for the following: marketing processes needed to successfully negotiate the simulation, learning objectives, pre-requisite knowledge and assessments. As the team leader for the design, development and deployment of MindSim's comprehensive on-line help systems covering every aspect of MindSim from e-commerce functionality to simulation play, Mr. Gallagher defined technical requirements, helped create look and feel of GUI, defined content requirements, coordinated authoring, built system, input data, authored content, setup and maintained virtual collaborative environment. He also developed learning modules on marketing principles for access from the on-line training center and designed and authored reference brochure in Pagemaker 6.5. He debugged and rebuilt the opening menu of the WarGames CD-ROM, designed and developed the installation CD-ROM delivered to MindSim subscribers. As an auto-run CD, it launched an executable allowing appropriate supporting software installation, viewing of the simulation case videos, and connection to mindsim.com. Mr. Gallagher also designed and programmed the customer care database in MS Access which tracked trouble ticket information by customer and incident.

Raytheon (1999), Consultant. Developed CBT lessons for Telcordia. Knowledge elicitation, storyboarding and instructional design. Gained experience with wireless telecom genres, types, processes, and troubleshooting.

Conference Papers, Presentations, and Other Publications

Simulation Representation using SCORM (2006), P. S. Gallagher and H Altalib. The Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) Volume: 2006 (Conference Theme: Training the 21st Century Joint Force.).

SCORM and Simulations (2006), P. S. Gallagher. The Society for Applied Learning Technology, 2006 Interactive Technologies Conference.

Design for Knowledge Management (2005), Presentation to the Innovations in e-Learning Symposium, George Mason University, Fairfax, VA.

e-Learning in Private Industry: an SAIC Perspective (2004), Presentation to the International City/County Management Association, University of Maryland College Park, MD.

COPs: The Killer App for Professional Development (2003), Presentation to the Society of Applied Learning Technologies, Arlington, VA.

The Internet Encyclopedia (2003), John Wiley and Sons, various article contributions.

Distributed Learning: Best Practices in Industry, Academia and Governmental Agencies (2002), SAIC, McLean, VA

Web-base Learning: Moving Beyond the Internet as a Research Tool (2000). Sprague, D. & Gallagher S. Paper presented at the 11th international conference of the Society for Information Technology and Teacher Education.

ISDN and Internet Video Conferencing (1999). Presentation for Classroom Connect. Baltimore, MD.

Determining the Effectiveness, Relevance and Appropriateness of Yamaha's Music in Education. Master's action research paper in partial fulfillment of a Master of Arts in Educational Technology, University of New Mexico 1997.

Integrating Culture and Technology (1998). Presentation for the New Mexico Media Literacy biannual conference: Vital Solutions: The Conversation Continues.

The Navajo Language CD Project (1998). Presentation for the National Gifted and Talented Conference. Albuquerque, NM.

The Gifted Programs of Navajo Preparatory School (1997). Presentation for the National Gifted and Talented Conference. Seattle, WA.

Computers in the Musical Classroom (1991). Presented for the NM Music Educators Association. Albuquerque, NM. January.

Memberships and Professional Affiliations

American Society for Training and Development (ASTD)
Association for the Advancement of Computing in Education (AACE)
International Association for Jazz Educators (IAJE)
International Society for Technology in Education (ISTE)
Knowledge Management Institute (KMI)
Society for Applied Learning Technologies (SALT)