Simulation Representation using SCORM

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ABSTRACT

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. When targeted towards learning, well-designed simulations can have a high level of learning transference which is an ideal in education and training. Meaningful learning experiences require a partnership of tools used to represent meaningful problems where learning and activity are considered inseparable and learning is embodied in tool usage. One type of learning environment that supports meaningful learning is the simulation. However, to realize the effectiveness of broadly using simulations for online learning, shareable content objects (SCOs) and resources should support the complex interactions required.

SCORM 2004 currently has robust affordances for online learning such as the sequence and navigation model that will allow flexibility in the design of learning interactions. However, it is not being used to support the integration of simulations as learning activities other than at the SCO level or in using external systems. It may be possible, however, to utilize these affordances along with specific SCO and asset typologies to begin designing and integrating simulations. To begin to understand the possibilities of this and other approaches, simulations need to be abstracted into a typology with specific characteristics and analyzed against various aspects of the SCORM to determine the best approach to SCORM-Simulation integration. This paper discusses the results of an initial analysis and analysis protocol development as well as the possible steps forward.

ABOUT THE AUTHORS

Patrick "Shane" Gallagher is a Senior Knowledge Engineer and project manager in the Strategies, Simulations, and Training Business Unit of Science Applications International Corporation (SAIC). Mr. Gallagher was the analysis team technical team lead and was the domain/knowledge engineer for the Joint Knowledge Development and Distribution Capability (JKDDC) project for the Department of Defense (DoD). Shane has extensive experience in designing and developing learning and knowledge architectures and systems and was also the principle subject matter expert in developing the strategic plan for Advanced Distributed Learning for the Air Force. Mr. Gallagher 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. Mr. Gallagher is currently finishing his doctoral dissertation at George Mason University in the development of an assessment of learning object content models for meaningful learning and continues to pursue models for convergence in the areas of e-learning and knowledge management. Also, Mr. Gallagher is leading an internal research and development project for SAIC in the design and development of new content object models to support learning and knowledge provisioning within smart enterprise systems.

Hasan Altalib has over 15 years of knowledge management (KM) and training experience in the private sector and consulting with government agencies. He has successfully applied his KM, and instructional design expertise on projects for the Department of Agriculture, Department of Interior, Department of Defense, Army, Navy, Marines, Air force, and the Joint warfighting Community. He has managed projects involving the design, development and implementation of knowledge management solutions, including knowledge portal design, constructing collaborative environments, knowledge mapping, and knowledge aggregation and dissemination systems. He also managed a number of performance support and courseware development efforts that include interactive performance modules, instructor-led and Web-based courses. In his current role as a team manger at SAIC Mr. Altalib manages the Knowledge Harvesting team that creates reusable knowledge objects synthesized from information objects, based on the object-oriented approach for content development. Mr. Altalib is responsible for managing the development of processes, business rules, metrics, tools and technology, metadata models and documentation that support knowledge object creation. Mr. Altalib has published various articles including, “Return on Investment Calculations for Electronic Performance Support Systems,” and “The Use of Mobile- Wireless Technology for Education. “

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Background - Problem Statement

As technology and specifically Internet and Web technology is further 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 to the informal instantiated in search and discovery, simulations, and electronic performance support systems (EPSS). Technological 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 the areas of human resource management with online learning in career tracking as well as competency management directly tying course credits and certifications to career paths. As an attempt to keep online learning more meaningful, the overarching tenet is to be learner-centric and these convergences are thought to begin to put the learner in control. New types of interactions and learning experiences 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). Prominent among these new approaches and techniques is that of simulations.

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).

As much as educational simulations are important tools to support learning, in the literature, as well as in discussions among scientists and practitioners, 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, sometimes two simulations having the same name can be very distinct in functionality and type (Maier and Grobler 2000).

However, the diversity in terms illustrates the diversity in purposes surrounding the development and deployment of simulations in the learning context. Such purposes include such things as learning to be a better manager, learning how to perform and function with a team (medical, flight, etc.), understanding systems through exploration (virtual labs, models, etc.) 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 which is an ideal in education and training. Transference is 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 using simulations on a broader scale through the use of standardized interoperable platforms such as standards conformant learning management systems (LMS).

Learning Technology Standards

For learning experiences to be managed, tracked, and reusable, they must be standardized in the way they are described and implemented (Sutcliffe 2002; Strijker 2004). 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 IMS Global Learning Consortium (IMS), the Institute of Electrical and

Electronic Engineers (IEEE), or the Dublin CORE (Duval 2004).

Specifications are developed by organizations such as the IMS or the Aviation Industry 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 learning object content models (LOCM) may be an implementation of one or more standards or specifications, a unique model or a hybrid of any or all. As an example of this fuzzy delimitation, IMS learning object (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. SCORM, considered a LOCM in the literature (Katz, Worsham et al. 2004) 2005; (Verbert, Klerkx et al. 2004) (Verbert and Duval 2004), is a hybrid of standards and specifications pulling from 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.

SCORM, being closely related to the other LOCMs prevalent in online learning (Verbert and Duval 2004), is also well-known and is implemented prolifically by mandate or for conformity across the Department of Defense, other U. S. Governmental agencies (ADLNet 2006), most e-learning content providers, and major corporations and institutions worldwide. SCORM is also extremely well-documented in its implementation and is referenced in thousands of articles in scholarly and peer-reviewed journals, books and conference proceedings (Google 2006).

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 could be considered generalizable to the greater universe of the current state of the standards- based LOCMs.

Advantages

There are many advantages to having specifications and standards in learning technology. Typically these center around the idea of interoperability or the ability for learning content to be used across different organizations or enterprises employing a LMS. 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 for the most part centers around 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 is sometimes referred to as repurposing (Doerksen 2002). Reuse is described as mostly unrealized to date due to the lack of policy and infrastructure that currently exists across organizations as well as cultural barriers that exist which do not allow real reuse. Initiatives such as ADL's CORDRA 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).

Simulations place in standards

Currently, simulations standards exist mostly in the form of the High Level Architecture (HLA) developed by the Defense Modeling and Simulation Organization (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 Department of Defense (DoD) and is integral to the modeling and simulation community. However, these types of 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 these two worlds separate. In progress, multiple entities are collaborating on ways to develop interoperability standards between simulations, simulation engines, and LOCMs such as SCORM. 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 an LMS. At this time, however, these specifications are still being addressed which is a preliminary step toward standardization by bodies such as the IEEE.

If simulations are to be realized for their contributions as pedagogical strategies for training and education, they must be able to be represented and function within that space. Just as SCORM allows the reuse of content objects, aggregations of those objects and their sequencing patterns, the same should be said of simulations for individual training.

Goals of the Paper

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 and 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. 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 and 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 paper is an attempt to use an analysis of an online simulation to establish a set of requirements that can then be used to assess SCORM for its strengths and weaknesses against implementing those requirements while maintaining such innate SCORM tenets such as interoperability and reuse. As a secondary but also very valuable goal, this study also performs a limited evaluation of the protocol and instruments used to conduct the study for subsequent efforts in SCORMs assessment.

Conceptual Framework

Simulation Descriptions

"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)."

Simulations model reality in various means and modes. According to Herz, if an object simulates something, it is a simulation (Herz 1997; Prensky 2001). Alessi described educational simulations as programs that incorporate learner-manipulated models accompanied with learning objectives for understanding each model (Alessi 2000). 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 definition, simulations are described by many terms and mean many things to many people whether designed specifically for learning or not. Prensky 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 (Prensky 2001). 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, which may also include case descriptions, presentations by a facilitator and modeling tools (Maier and Grobler 2000). To understand the requirements of a simulation, it is important to accurately describe what a simulation is and what it does with discrete terminology usually found in a taxonomy.

Simulation Types

There are several descriptions and taxonomies developed to describe and classify simulations (Alessi 2000; Maier and Grobler 2000; Prensky 2001; Sulistio, Yeo et al. 2004; Aldrich 2006) ranging from the very simple to the more complex. Sulistio developed multiple taxonomies based upon simulation attributes and components in distributed systems (Sulistio, Yeo 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 paper is that of Maier and Grobler. It makes use of Alessi's prior work but adds some modification and expansion to it resulting 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 Table 1).

As robust as this taxonomy appears to be, there are still some missing attributes and assumptions that may or may not necessarily be true. For example, functionality areas may not apply as indicated if the single person user type is actually a small group playing as one. Also,

Table 1 Maier/Grobler Simulation Taxonomy (Maier and Grobler 2000)

Underlying model	Human–computer interface	Functionality
Real-world domain Business Other Generality of model in regard to domain Special area of real- world domain Whole domain Structure Feedback-oriented Process-oriented (mostly without feedback) Behavior Deterministic Stochastic Progress of time in simulation engine Discrete Continuous Role of simulation model Active generation of decisions Clearing device for users’ decisions Influence of external data With such influences Without such influences Domain of variables Integers Real numbers	Chance of intervention while simulating Discrete periods Simulation in one run Mode of users’ input Policy-oriented Decision-oriented Mode of display Text Multimedia Mode of Interaction Keyboard Mouse	Number of users possible Single person Multi person Degree of integration Stand-alone simulation Integration in computer- based environment Main area of application Modeling-oriented Gaming-oriented Use of teachers/ facilitators/coaches Totally self-controlled learning Support by teacher/ facilitator/coach Transparency of simulation model Black-box Transparent-box Advancing of time Clock-driven User-driven

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 dgree of fidelity of the underyling 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.

PharmaSim

As computer based simulations are becoming a popular and useful tool for learning and applying business concepts, they are becoming more and more prevalent in the world of e-learning. They 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 much of the realism of making business decisions in a learning environment. A prominent online simulation for the teaching of marketing business decision is PharmaSim (Interpretive 2006). PharmaSim was developed by Stu James several years ago and is located on the Web at http://www.interpretive.com/pharmasim. PharmaSim is a highly successful educational simulation that is currently in use by such business schools as Drexel and Darden.

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 will need to 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, Kinnear et al. 1999).

The PharmaSim marketplace is similar in nature to the US market. The 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 year, the participants make decisions on pricing, advertising, consumer and trade promotion, distribution, and sales force for the Allround brand (James, Kinnear et al. 1999).

As a member of the marketing management team, learners will 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

Table 2 PharmaSim Characteristics from Taxonomy

Underlying model	Human–computer interface	Functionality
Business Feedback-oriented Deterministic Discrete Clearing device for users' decisions Without external influences Real numbers	Discrete periods Decision-oriented Text Keyboard	Single person (or team) Integration in computer- based environment Modeling-oriented Support by teacher/ facilitator/coach (computer- based) Black-box User-driven

(Interpretive Software 2006).

As the simulation progresses, new issues and problems will arise. In the second decision period, participants are able to reformulate the Allround brand. After several more periods, they will have the opportunity to create a line extension of the Allround brand. Later, players will 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, the participants are also given more control over marketing mix decisions as the game progresses. For instance, learners will 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, Kinnear et al. 1999).

Based on these characteristics PharmaSim could be categorized on Maier's taxonomy as described by the terms in the table 2 (see Table 2).

As a Use-Case for Requirements Development

To better understand the gaps of SCORM 1.3.1 in relationship to developing and integrating simulations within the SCORM environment, PharmaSim was used to develop a baseline requirement set representing the requirements necessary to field an online simulation with collaboration. The extracted requirements set represents an analysis of the functional areas and user/system interactions necessary for the functionality of an exemplar simulation. This was also undertaken with the following overarching tenets in mind: maximum reuse across multiple environments, interoperability, and durability - in other words the SCORM vision which tends to represent the vision of all entities involved in the standardization of online learning of all types.

The various functional areas of the simulation as well as those surrounding the entire learning environment

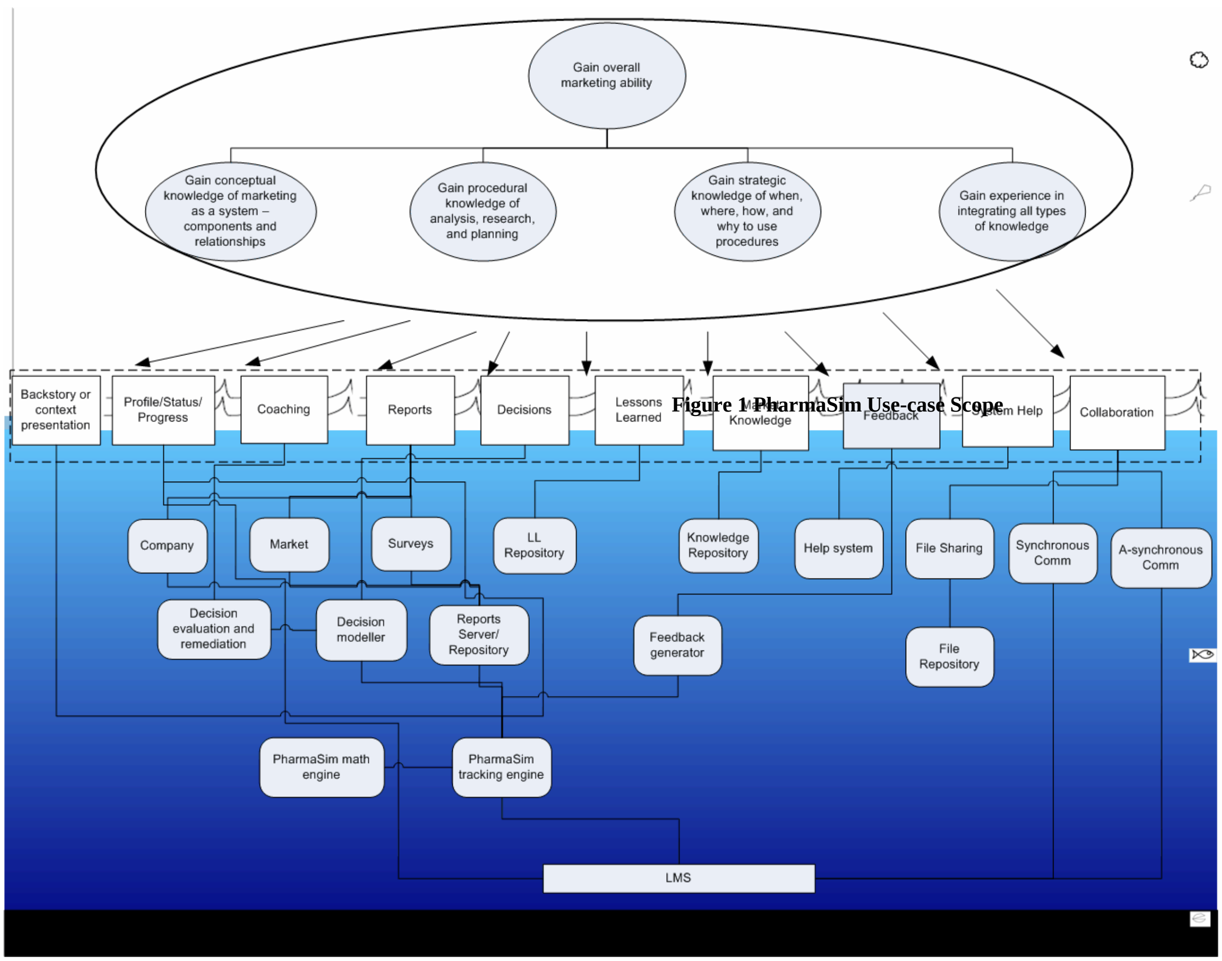

Figure 1 PharmaSim Use-case Scope

were diagramed as a use-case scope diagram describing what functions were considered sea (user) level, what were summary level, as well as those at sub-sea level functions. Figure 1 (see Figure 1) represents the scope of the PharmaSim use-case from which the requirements and sub-requirements were derived from the functionality.

SCORM Categories for Analysis

To develop an analysis framework, it was necessary to decide what needed to be analyzed. In terms of SCORM, it, like its related LOCMs have a technical architecture based upon the specifications and standards that comprise it. This architecture is described in the 2004 SCORM books "SCORM Content Aggregation Model (CAM)," "SCORM Run-time Environment (RTE)," "SCORM Sequence and Navigation (SN)," as well as the "SCORM 2004 Overview (ADL 2004)." However, as indicated in the Overview, the areas, or key aspects of SCORM described in each book overlap significantly. This is not at odds for breaking out categories for analysis but is an important concept in the overall analysis methodology. It was important, however, to separate out the metadata schema as a separate category of analysis. Metadata taken from the IEEE Learning Object Model (LOM) (Duval and Hodgins 2003) resides at each level of content aggregation and is an important component for SCORM's overarching tenet of reusability. Also, the Content Aggregation Model was viewed only as the structural component of content. The manifest discussed at length in the CAM was not viewed as a separate entity but as a place where various functional data were stored.

The categories for analysis then are based upon the structural model of content aggregation, metadata model, the run-time environment, and simple sequencing logic and data passing subdivided into sub-categories forming the actual units of analysis. The categorical structure is illustrated in the table below (see Table 3).

Framework Design and Description

The assessment framework design is based upon three main assumptions. These assumptions represent the beginning development of a protocol to assess various LOCMs for their strengths and weaknesses in relation to a set of build requirements for the purposes of improving, re-designing, or designing a new LOCM. The first assumption is that it is possible to compile a set of functional requirements for building an online learning environment that can embody specific pedagogical models and represent an associated set of instructional strategies and learning outcomes. For example, learning with simulations represents a pedagogical model and presenting coaching on decision-making within the simulation represents an instructional strategy. Depending on how the strategies are employed, specific higher-order learning outcomes such as "evaluation" (Bloom 1956) could be realized.

The next assumption is that experienced SCORM developers have the knowledge and expertise to analyze a requirement or requirement set and understand how various aspects of the SCORM technical architecture is relevant or would be applied in the realization of the requirement or set. For example, if a requirement calls for data to be passed to the LMS, the developers would realize that in the requirement and most likely understand which area of the run-time data model would be affected. The third assumption is that experienced SCORM developers have an understanding of maintaining conformancy to SCORM in all its aspects. Developers in these cases could be programmers, instructional technologist, or instructional system designers who understand and have significant experience in applying SCORM 1.3.1 in their development.

Methodology

Overview

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).

Table 3 SCORM Analysis Categories

Content Aggregation (Structure)	asset shareable content object root aggregation level non-root aggregation level
Metadata	general metadata educational metadata
Run-time Environment	API data model
Sequencing	logic data passing

In the field of instructional design, a gap analysis is a crucial component of the analysis phase in the 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 et al. 1999), ADDIE concentrates on the formulation of objectives as a central tenet with the basic approach beginning with a problem and needs analysis resulting in concrete design goals and objectives.

Within the ADDIE model, a gap analysis occurs as the performance analysis or front-end analysis used for identifying the nature of a problem is applied as well as in the needs assessment to determine instructional needs. Gap analyses use the terms "what is" and "what should be" for identifying the existing and ideal states. 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 and Kazanas 1998).

This paper made use of the gap analysis methodology to identify the criterion known as the Simulation Learning Requirements (SIMLREQ) using the existing state of SCORM 1.3.1 as the condition, identify the gaps between the states, and attempt to identify their causes and symptoms.

As SCORM is by one definition a framework for developing or authoring learning content (LOM Research Agenda), it is necessary to assess it in the authoring or development context. To assess its development capabilities against the SIMLREQ, indirect measures were used. These indirect measures consisted of measures of relevance between a given requirement and the assessment categories described previously. Also, each requirement was assessed for the developer's overall confidence that it could be developed within the SCORM framework while still maintaining conformancy. Finally, if the developer has little confidence in maintaining conformance, then the gaps were asked to be identified. An overall assumption in pinpointing strengths and weaknesses was that an inverse relationship between confidence and relevance by assessment category would elicit the categories weak in supporting the requirement. Conversely a positive relationship would point to their strengths. These relationships were then explored with probing questions and interviews.

SIMLREQ Development and Survey

The purpose of developing the SIMLREQ was to serve as the criterion in the gap analysis methodology. The criterion is essentially a set of requirements that was reverse engineered from an in-depth analysis of PharmaSim and correlated to simulation-based instructional strategies.

This process occurred through the use of sea-level use-case development based upon Cockburn's methodology (Cockburn 2001), analysis, and functionality aggregation across PharmaSim producing an initial set of requirements. Next, content analysis was undertaken on documentation of PharmaSim and on the current literature concerning simulation learning. These analyses resulted in a more robust set of requirements representing online instructional strategies supporting simulations as the pedagogical model. To help generalize the SIMLREQ to other environments, a reasonable set of learning outcomes could also have been established with each learning outcome correlating to appropriate instructional strategies. However, that activity was currently outside the scope of this paper.

The resulting requirements employed by the SIMLREQ consisted of 13 sea level requirements each having several sub-sea level requirements. The sub requirements were designed to target various aspects of the SCORM categories as well as reusability. For a developer to rate a sea level requirement, all sub requirements needed to be evaluated for impact and constraints affecting how the developer would think of them in terms of granularity, data passing, or discoverability to name a few. Table 4 illustrates the complete requirement set of the SIMLREQ with only #4 expanded due to space.

meeting the each requirement. This design, even in a limited application, allowed the gathering of many data points to develop a statistical profile.

Data Collection

Data collections focused on two main areas: data collection in support of the gap analysis and data collection in support of the goal of formative evaluation of the instrument for future research. The following discussions will be limited to that of the first goal.

Subjects

The subjects of the data collection consisted of a very small population of IT developers and instructional technologists with several years of project experience using and developing with SCORM as well as non-SCORM courseware and LMS integration projects. However, SCORM 1.3.x experience was limited to approximately one year.

Table 4 SIMLREQ List

1. User Selects Role and Scenario:
2. User Views Case and is Welcomed into Simulation:
3. User Views Status (Progress within simulation / Summary of decisions):
4. User Obtains Coaching Upon Request: 4.1. After User has created profile and has viewed case/welcome, coaching is available to that user when modeling or making decisions 4.2. Upon request coaching will provide decision making information depending on the type of decision and the potential outcome of that decision. 4.3. Upon request coaching will provide decision making feedback depending on the impact of the decision being made by the user when modeling a decision (what if), based on set simulation parameters. 4.4. Coaching will be available to other entities outside this simulation who are seeking marketing domain knowledge
5. User Views Available Reports:
6. User Inputs Decision Data:
7. User Provides End of Period Reflection:
8. User Inputs/Saves Lessons Learned:
9. User Searches and Views Lessons Learned:
10. User Accesses Market Knowledge Base:
11. System Provides Feedback
12. User Accesses System Help
13. User Collaborates with others Throughout all Activities

The survey design was a matrix comprised of 13 rows (requirements or criteria) and 10 columns (SCORM categories or condition) used for assigning relevancy to a SCORM category by requirement. A Likert scale was used with 1 being least relevant and 5 being most relevant. Also, additional columns were added containing Likert scale questions concerning overall confidence in SCORM's ability to meet each requirement and it potential for reuse. Again, the scale was 1 for least confident and 5 for most confident. Finally, 2 columns were added at the end of each row to gather qualitative data around the open-ended questions concerning potential gaps and issues in

Implementation

The survey was delivered to the subjects via e-mail as an attached electronic spreadsheet. The first page of the spreadsheet contained an introduction, contextual information about the PharmaSim simulation and directions for filling out the survey.

Participants were asked to complete the survey by analyzing each requirement presented including its sub-level requirements. After understanding the requirement thinking about its technical requirements, they were asked to perform the ratings as described above. After completing the survey, the subjects returned the spreadsheet via email attachment after which the quantitative results were input into SPSS for analysis.

Following the survey-based data collection, those available participated in one-on-one question and answer sessions in the form of an interview and email questions.

Analysis

Using the results of the survey, the causes and symptoms were examined through the use of various quantitative analysis methods as well as limited qualitative analysis.

Variable descriptions used for quantitative analysis were the overall confidence values with extensions and relevancy values for each area of the SCORM 1.3.1 technical architecture as indicated previously (see Table 3). These data were stratified and analyzed based upon each requirement in the SIMLREQ (see Table 4).

Exploratory analysis and means comparisons were used to look for the general condition and trends in the data. In looking for correlations between confidence and SCORM areas, regression analysis and scatter plots were used.

Results and Implications

As the scope if this paper was limited to a pilot study in the course of a more robust assessment, participation was limited and the results would be difficult to validate as a true assessment of the strengths and weaknesses of SCORMs capabilities in meeting the requirements contained within the SIMLREQ. However, the results do offer insight into possible areas of concern that merit further exploration.

In looking at the comparison of the means of the overall confidence ratings the requirements could be met using SCORM even with extensions, it became apparent that several of the requirements had mean score values ≤ 3 with the lowest being requirements #4, #10, and #13 presented below (see Table 4). The other lower values were for requirements #3, #6, #8, and #9. As the participants' SCORM experience was well documented, values of 3 or lower were considered low to no confidence. In the lower scoring requirements, #4 involved coaching and decision support tied to data from #6 which in essence is the simulation engine. #13 involved collaboration activities to support decision making and knowledge sharing. Others involved contributing to a knowledge base and nearly all required reusability as components for other enterprise systems.

Statistically, these data were not robust enough for any real claims, however, interview data suggested that if the SCORM as a specification was understood more broadly, reuse as a concept was better understood, and the requirements listed were more specific (i.e. what type of coaching,), the confidence level would most likely have been even lower.

In terms of relevance of each area of the SCORM technical architecture to requirement, it initially appeared that lack of understanding and experience using sequencing was a factor in the scores. For example, the categories of simple sequencing logic (rules), sequencing data passing, root and other aggregation levels were all mostly low in relevance. Interview data confirmed that development was still being thought of without sequencing as a tool. Interestingly enough, the other low relevance scores belonged to the metadata categories. This leads to the belief that even though reuse was embedded in most of the requirements of the SIMLREQ, it was not being considered when thinking about their implementation. Further evidence of the scope of the developer's thinking came to light in the scores of the RTE categories – API and data model. These categories and especially that of the API, were considered highly relevant to the nearly all of the requirements. This leads to the belief that most of the concern when developing SCORM-based requirements centers around that of the integration to the LMS in terms of tracking but not necessarily on what is needed for internal data passing, SCO sequencing or intra-SCO data passing all concepts stemming from the addition of simple sequencing to SCORM.

Finally, in the correlation of SCORM category relevance to confidence, there emerged two possible correlations. These occurred between overall confidence with extensions measures and that of both RTE categories. When running a linear regression, a partial regression plot showed tendency to a positive correlation for the RTE data model but more significantly, a partial regression plot showed a stronger tendency toward an inverse correlation between confidence and the RTE API and exhibited a Pearson's Correlation Coefficient of -.649. If focusing on the RTE scores considered the most relevant by the subjects, as the relevance of the API was rated higher per requirement, the confidence that SCORM could meet that requirement dropped. This would be a potential area of exploration as a weakness in SCORM's ability to meet the requirements.

Conclusion and Next Steps

In conclusion, this paper has highlighted some important issues in the ultimate goal of assessing SCORM for its ability to meet and deliver simulations as well as other types of pedagogical models. However, to begin to understand the underlying issues in more depth and with more accuracy it is apparent that participants of the study need to have depth and breadth in understanding the complete SCORM architecture and how it can effectively support enterprise learning. That being said, there is concern that merits exploration in the RTE API in handling advanced requirements such as those produced in creating a simulation.

Another important step taken in this process is the development of the simulation requirements in the form of the SIMLREQ and associating them with a taxonomy. Once requirements can be generalized and categorized by simulation type or even other types of pedagogical models, they can then support the development and reuse of those requirements as reusable models. Such information could easily exist as patterns or templates of sequencing logic associated to specific SCO/asset functionality. It is conceivable to develop and map multiple types of simulations as represented in the taxonomy in Table 1 as sequencing/SCO reusable templates once requirements are developed, compiled, aggregated, and generalized.

It was also noteworthy that the one requirement calling for collaboration (#13) was rated very low. This is not surprising as SCORM is well recognized as not supportive of collaborative learning environments (Kraan and Wilson 2002). Collaboration activities may make up another area of weakness in integrating SCORM with simulations. Although collaboration may be supported in part by various LMS's, in terms of reusability and interoperability this may be an area worth more exploration. Currently some are thinking of collaboration in terms of generic services discovered dynamically. Others are extending and modifying SCORM to support a cooperative SCO (Young-Sik and Seong-Hun 2005).

The next steps necessary are to first, analyze the gaps in SCORM more robustly using an expanded requirement set and diverse and experienced subject set, followed by design tenets of modifications or extensions necessary for SCORM to fully support these requirements. Once gaps are established based upon various types of requirements, development techniques, patterns, modifications, and/or extensions to SCORM could then be proposed that would support these requirements hopefully allowing simulations to exist as a pedagogical model fully deliverable within the standardized e-learning environment.

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