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THESIS

INTEGRATION OF EXPERIENCE API INTO CDET'S E-LEARNING

by

Clayton C. MacAloney

June 2016

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The increased availability and use of online devices has the Marine Corps College of Distance Education and Training (CDET) looking at Experience API (xAPI) for ways to improve the accessibility, effectiveness, and efficiency of the educational instruction they provide. This thesis recommends a way for CDET to incorporate xAPI into the courseware currently delivered by their learning management system (LMS), MarineNet. Research was conducted into how learning objectives, online assessments, and xAPI can create a learning objective performance value (a measurement of a student's proficiency in a specific learning objective). A prototype system consisting of a LMS, Learning Record Store (LRS), and xAPI courseware was developed, and learning experiences linking course assessment questions to learning objectives were extracted to the LRS. The learning experiences were then analyzed to calculate learning objective performance values, which provide the ability to determine students' strengths and weaknesses in specific subject areas. This enables tailored curriculums that allow time and resources to be spent in subject areas that most benefit the student and the Marine Corps, while maximizing the effectiveness and efficiency of their e-learning courseware.

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INTEGRATION OF EXPERIENCE API INTO CDET'S E-LEARNING

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The increased availability and use of online devices has the Marine Corps College of Distance Education and Training (CDET) looking at Experience API (xAPI) for ways to improve the accessibility, effectiveness, and efficiency of the educational instruction they provide. This thesis recommends a way for CDET to incorporate xAPI into the courseware currently delivered by their learning management system (LMS), MarineNet. Research was conducted into how learning objectives, online assessments, and xAPI can create a learning objective performance value (a measurement of a student's proficiency in a specific learning objective). A prototype system consisting of a LMS, Learning Record Store (LRS), and xAPI courseware was developed, and learning experiences linking course assessment questions to learning objectives were extracted to the LRS. The learning experiences were then analyzed to calculate learning objective performance values, which provide the ability to determine students' strengths and weaknesses in specific subject areas. This enables tailored curriculums that allow time and resources to be spent in subject areas that most benefit the student and the Marine Corps, while maximizing the effectiveness and efficiency of their e-learning courseware.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADL	Advanced Distributed Learning Initiative
API	Application Programming Interface
CDET	Marine Corps College of Distance Education and Training
CSV	Comma-Separated Values
EDCOM	Marine Corps Education Command
EOC	End-of-Course
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
ICDE	Internet Content Delivery Engines
JSON	Java Script Object Notation
LMS	Learning Management System
LRS	Learning Record Store
MCU	Marine Corps University
PIF	Package Interchange File
PME	Professional Military Education
SaaS	Software as a Service
SCO	Shareable Content Object
SCORM	Shareable Content Object Reference Model
TLA	Training and Learning Architecture
URL	Uniform Resource Locator
UUID	Universally Unique Identifier
VM101	Passenger Vehicle Maintenance Course
VM201	Commercial Vehicle Maintenance Course
xAPI	Experience Application Programming Interface
XML	Extensible Markup Language

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I. INTRODUCTION

The United States Marine Corps' Education Command (EDCOM), also known as Marine Corps University (MCU), is tasked with the development, delivery, and evaluation of the professional military education (PME) conducted through resident and non-resident courses throughout the Marine Corps ("MCU Mission Statement," n.d.). One of MCU's goals to continuously improve their quality of education is to "Leverage and integrate state-of-the-art information and education technologies... to provide students a relevant educational experience in the most effective and efficient manner." ("Goal 3," n.d.). An important part of maintaining the readiness of the Marines under high operational tempos throughout the world is providing effective and efficient PME in the form of quality e-learning products. MCU relies on their subordinate unit, College of Distance Education and Training (CDET), to provide the e-learning infrastructure and products needed to support distance learning.

One of the systems CDET uses to administer e-learning courses is MarineNet. MarineNet is a learning management system (LMS) that allows CDET to deliver Shareable Content Object Reference Model (SCORM) compliant e-learning courses and track students' completion status. The SCORM standard was developed in 2000 and last updated in 2009. Since then, efforts by experts have focused on developing new standards that provide a wider range of flexibility in the capture, storage, and analysis of all learning experiences that occur in e-learning. One such standard developed by Advanced Distributed Learning (ADL) was Experience API (xAPI). The draft version of the MarineNet Five Year Strategic Plan (FY14–FY18) lists the development of xAPI courseware as a means of enhancing their capabilities to deliver effective, responsive, and relevant e-learning resources (Michael Gavin, personal communication, February 2, 2016). For the use of xAPI to be effective in e-learning, a thorough analysis needs to be conducted of the types learning experiences to be captured in order to provide educators the relevant data necessary to make effective decisions pertaining to students, courses, and curriculums.

This thesis researches topics in education, course structure and development, and enabling technologies that support e-learning courses, to determine the learning experiences to capture with xAPI. This provides CDET the types of relevant data needed to improve their e-learning courses, methods at which to capture and store the experiences as data points, and ways to analyze the data to provide a useful metric to make educational decisions.

The capture of key learning attributes and the follow-on analysis of that data requires examining a student's learning activities to determine the effectiveness of the instruction. This thesis focuses on the capture of key learning attributes by seeking to use online assessments to place a percentage value on how much a student has learned by tracking elements of their learning activities and extracting them to a format that can be used for follow-on analysis by educators. Specifically, this thesis examines how learning objectives, online assessments, and xAPI measure a student's performance in specific subject areas by capturing and extracting learning experiences to a Learning Record Store (LRS).

A. THESIS OBJECTIVE

The objective of this thesis is to provide CDET with a method of incorporating xAPI into their e-learning courseware enabling them to improve the level of education. The method recommended to CDET captures and stores learning experiences using xAPI that allow the establishment of individual and collective learning objective performance values. The calculated performance values can then be used to improve the level of education they provide by allowing a more detailed analysis of a student's knowledge leading to a more tailored educational experience or improvement to the overall curriculum. The prototype system used to demonstrate this method consists of an e-learning course with xAPI and utilizes existing software as a service (SaaS) learning technologies to create a new way to use learning activities to support e-learning.

B. THESIS OUTLINE

Chapter II provides research and background information that will assist in understanding the prototype system's purpose, creation, technologies, and end-state. The following are the topics discussed: assessment of student learning, CDET's current e-learning system elements and architecture, enabling e-learning technologies, and xAPI.

Chapter III discusses the stakeholders and three use cases used in the development the prototype system. The stakeholders used include the student, course instructor, course developer, and institutional administrator. The three use cases describe the prototype courseware creation, capture and storage of assessments, and extraction of data.

Chapter IV provides a full description of the prototype system's architecture, courseware, and components. Also included is a complete demonstration of the prototype system's capture and extraction of learning experience data, and follow-on analysis of student learning objective performance values.

Finally, Chapter V summarizes the research conducted and recommends topics for follow-on research in areas related to assessments of student learning and learning experience data analysis.

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II. BACKGROUND

E-learning uses varying levels of electronic technologies to access educational materials. The amount and level of electronic technologies will differ depending on the type of course. According to John Sener, e-learning is typically used in the following types of courses: synchronous distributed courses, web-enhanced courses, blended or hybrid classroom courses, online courses where all activities are conducted online without face-to-face interaction, or flexible mode courses (2015). Without face-to-face interactions, it can be challenging to determine how much a student has learned during a course.

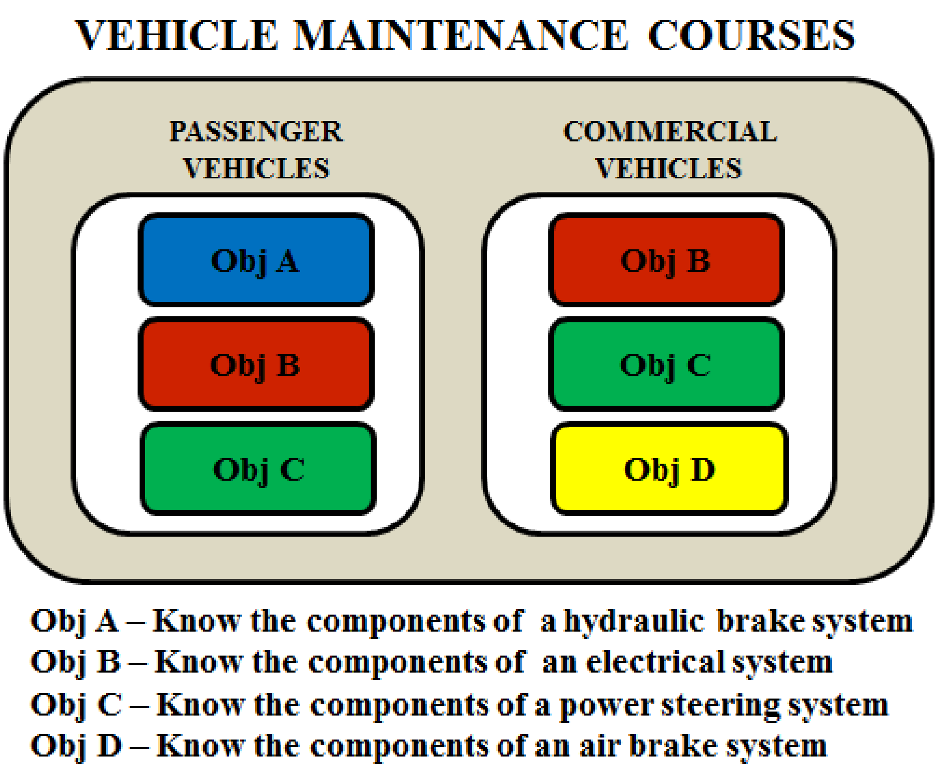
A. ASSESSMENT OF STUDENT LEARNING

When determining how much online course students have learned, an important measure to evaluate is their performance. It is expected, throughout the course that the students' performance in subject-related tasks will improve. According to Patrick, Edwards, Wicks, and Watson's report created for the International Association for K-12 Online Learning, two measures used to determine changes in performance are proficiency and growth (2012). This same report states proficiency is used to assess students' knowledge at a specific time in their learning, while growth assesses students' "proficiency, skills, and knowledge gained in a given period of time" (Patrick et al., 2012, p. 9).

Effective assessments need to be administered and evaluated to gauge student performance levels in different subject areas. The Eberly Center at Carnegie Mellon University states "assessments should reveal how well students have learned" and "assessments, learning objectives, and instructional strategies need to be closely aligned so that they reinforce one another" ("Why should assessments," n.d.). Course learning objectives should be clearly stated and reflect what a student should learn during the instruction. Linking assessment questions directly to individual course learning objectives will allow a student's proficiency in those learning objectives to be determined. By determining these individual learning objective proficiencies a more detailed assessment can be made as to the amount of learning that occurred in the course.

Comparing students' individual learning objective proficiencies over time will assist in determining their growth in the associated subjects. Repeated and similar learning objective proficiencies of courses within a given subject can be compared and analyzed to assess total learning growth in that subject or their subsets. Figure 1 is an example of two different courses with the same subject matter (vehicle maintenance) with overlapping learning objectives.

Figure 1. Example Subject and Subset Courses with Repeated Learning Objectives.



VEHICLE MAINTENANCE COURSES is the subject and PASSENGER VEHICLES and COMMERCIAL VEHICLES are its subset courses. Both passenger and commercial vehicles could have the same electrical and power steering systems (Obj B & Obj C), which could lead to repeated learning objectives. Typically they would have different brake systems, as seen with Obj A & Obj D.

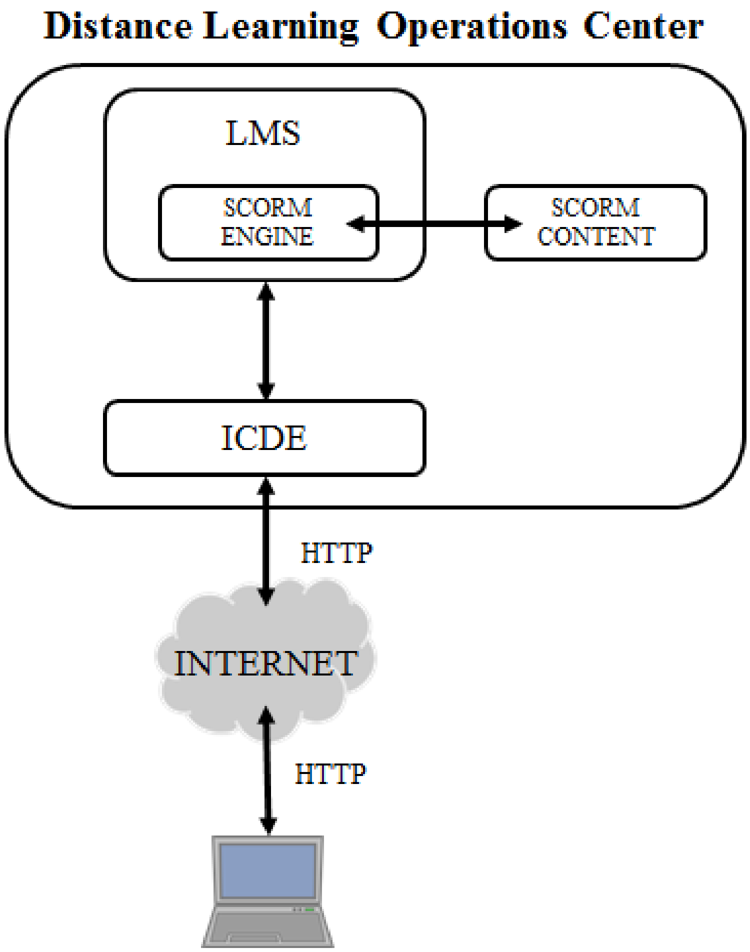
The use of learning objectives proficiencies to determine a student's knowledge growth in a particular subject area or one of its subsets can be a method in determining their strengths and weakness in those areas. Leaders and educators can analyze this data to create a more tailored and effective learning experience for the student while providing a more efficient use of educational resources.

B. COLLEGE OF DISTANCE EDUCATION AND TRAINING

CDET is tasked by their higher headquarters, EDCOM to "design, develop, deliver, evaluate, manage, and resource distance learning products and programs across the Marine Corps training and education continuum in order to increase operational readiness" ("Welcome to CDET!," n.d.). The distance learning network CDET uses MarineNet to deliver, evaluate, and manage their e-learning courses. Department of Defense Instruction 1322.26 paragraph 6.2 states "All acquired or developed DOD systems shall conform to the SCORM (current version) to ensure accessibility, durability, reusability, maintainability, and interoperability" (Department of Defense, 2006, p. 4). CDET conforms to this requirement by publishing all their e-learning courseware on MarineNet as SCORM compliant.

The network architecture MarineNet uses to support their e-learning courses, seen in Figure 2, is located at CDET's Distance Learning Operations Center and consists of a LMS, SCORM Engine, and Internet Content Delivery Engines (ICDE) and is seen in Figure 2 (College of Distance Education and Training, 2012). The LMS is server-based software managing the course catalog, student enrollment, and tracks data specified within the SCORM compliant course. According to Michael Gavin (personal communication, November 12, 2015), CDET currently tracks the following student data in the LMS: enrollment date and status, completion date and status, course grade, number of course launch attempts, total time course opened, and varying course specific custom data.

Figure 2. MarineNet Network Architecture. Adapted from College of Distance Education and Training (2012).



The SCORM Engine is part of the LMS and it has two primary functions. First, it is used to make SCORM Application Programming Interface (API) calls from the LMS to the SCORM courseware servers to display content. Second, it relays course and student data transactions back to the LMS for tracking and storage. A limitation with CDET's LMS/SCORM architecture is the requirement for a student to maintain a constant connection (via the Internet and ICDE) to the LMS for the content delivery and tracking to occur.

Most e-learning courses hosted on MarineNet consist of self-paced content modules and have associated assessments in the forms of in-course quizzes or end-of-course (EOC) exams. Of the courses that currently require students to participate in an assessment, all have questions that require only multiple choice answers (Michael Gavin, personal communication, February 2, 2016). In the *MarineNet Courseware Development Technical Standards Version 2* document, CDET discourages course developers from using matching text responses and completely restricts the use of essay, spoken voice, or file uploads responses in their assessments (College of Distance Education and Training, 2012). This is due to evaluator requirements to formally grade performance of responses for these methods.

C. ENABLING TECHNOLOGIES

1. Software as a Service

SaaS is a service model of cloud computing providing customers the ability to access software applications on a service provider's cloud infrastructure over a network or through the Internet (Grance & Mell, 2011). SaaS is limited in scope to the services the software provides and does not allow a customer the ability to influence the physical storage, processing, operating systems, location, or other resources that Platforms as a Service or Infrastructure as a Service might offer. There are many service providers who are using SaaS to provide software solutions that support e-learning. Three services this thesis will focus on are course generation software, LMS, and LRS.

SaaS brings with it many benefits to the customer. Costs are brought down by eliminating the requirement to maintain costly infrastructure and software on site. The costly management of resources (servers, software, facilities, power, data backups) is transferred from the customer to the service provider responsible for maintaining the infrastructure. This affords smaller customers access to technologies and infrastructure that might otherwise be too costly to setup and maintain on site. It also gives customers access to hardware and software upgrades without risk of disruption to their operations. Services are typically available through most devices and from locations with connections to the internet. Different SaaS pricing strategies (see Table 1) allow customers to pay for the amount and type of services they require leading to a more efficient use of money and resources.

Table 1. SaaS Pricing Strategies. Adapted from Jäätmaa (2009).

Cost Based	
Flat Pricing	• Fixed price for unlimited use of service, typically without up-front fees
Tiered Pricing	• Pricing is based on package of services
Performance-based Pricing	• Pricing based on theoretical throughput of the system such as MIPS (Million Instructions per Second)
User-based Pricing	• Pricing is based on the number of users that utilize a collection of service capabilities over a given period of time.
Usage-based Pricing	• Pricing is based on customers' actual usage on a transaction basis.
Value-based	
Penetration Pricing	• Market segments where buyers have high price sensitivity are targeted.
Skim Pricing	• Market segments where buyers are relatively insensitive to price and have high search costs are targeted.
Hybrid Pricing	• Combines elements from penetration and skim-pricing.

a. Course Generation Software

Course generation software allowing users to author online courses that are SCORM 1.2/2004 compliant and compatible with a LMS have become readily available as a SaaS. Some of the companies that offer these services are Easygenerator, SmartBuilder, Izzui, and myUdutu. These companies provide varying levels of services and options for free or on a tiered based pricing strategy. Examples tiered pricing is based on are the amount of courses created, number of users, types of assessment questions and content allowed for upload, and types of course templates available. The following are the services a provider's software can include: learning objective creation, basic and advanced content upload and integration, assessment creation, xAPI statement creation and extraction, online course hosting with internal LMS or as webpage, and publish courses in SCORM compliant format. Course generation software allows a person with little knowledge in code writing to create an online course that incorporates common e-learning technologies through easy to use graphical user interfaces.

b. Learning Management Systems

A LMS is software that allows the management and administration of online courses and their users (students, instructors, administrators). Some companies that offer LMSs as SaaS are TalentLMS, Litmos LMS, WizIQ LMS, and LatitudeLearning LMS. LMS providers implement pricing strategies based on the levels of services and options provided and are tiered based, usage-based, or user-based. Examples of items the LMS pricing strategies can be based on are the amount of courses and users, reports and analytics available, pre-authored course catalog, and languages available. The following are the types of services a provider's LMS software can include: course hosting, assignment of user roles, curriculum course management, enrollment request management, report course completion status, report course assessment performance value, and administer course surveys. These LMS services enable e-learning by providing a means for students, instructors, and administrators to participate in educational experiences without the costly infrastructure typically required to host and administer online courses.

c. Learning Record Stores

Learning record stores are data repositories that store experience statements sent from systems that have incorporated xAPI into their software. Two SaaS LRSs found available were Watershed LRS and Saltbox's Wax LRS. It is more common to find an LRS as an open source download for hosting on a local server. Most SaaS LMS providers offer an integrated analytic reporting capability with varying levels of user tracking. Saltbox offers free services or a tiered based pricing strategy for a larger statement storage capacity. The following are the types of services Saltbox and other downloadable LRSs offer: xAPI statement storage, export captured JavaScript Object Notation (JSON) to comma-separated value (CSV), and statement analytics and reports based on activity and user. These LRS services enable e-learning by providing a repository for administrators and instructors to store captured student experiences for later use in the analysis and improvement of the overall educational experience.

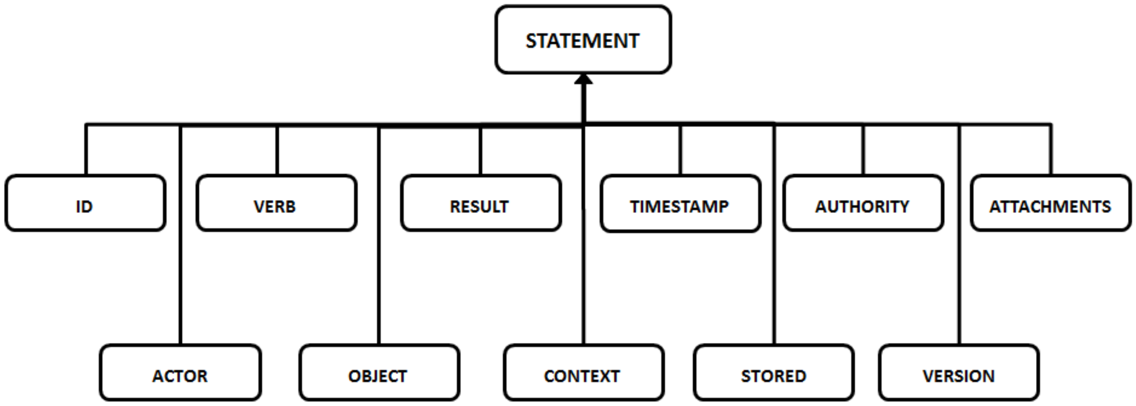
2. Experience API

Experience API's development was facilitated by ADL Initiative as a means to overcome the limitations in using SCORM and also to capitalize on the new devices and technologies capable of expanding the e-learning environment ("xAPI Background & History," n.d.). A focus of SCORM development in 2000 was to standardize online course content to ensure compatibility and content delivery across different LMS platforms. Since 2000, the methods of delivering content in e-learning has evolved from an LMS only environment to include reading news articles, watching online presentations, using mobile apps, or simulator training ("Experience API," n.d.). ADL developed xAPI to capture learning occurring in these emerging delivery methods and for data collection to provide "all types of learning activity data that can be analyzed and correlated to productivity and performance metrics" ("xAPI Background & History," n.d.).

Experience API was created as a collection of four sub-APIs. For the purpose of this thesis, only Statement API will be discussed. The Statement API is used to track and store learning activities in a structured data format ("xAPI Architecture Overview," n.d.). The repository where all xAPI generated learning experience statements get stored is called the LRS. ADL's website states the LRS is responsible for storing and controlling access to the data created by the statements, and for the validation of the statement's format when received in the LRS to reduce issues with other systems accessing the data ("ADL LRS," n.d.).

The data format used to create and store to the LRS is JSON. JSON was designed to be a data-interchangeable language easily read by both humans and machines ("Introducing JSON," n.d.). This format allows maximum flexibility for people and systems conducting analysis on the data. The xAPI statement data model shown in Figure 3 depicts the eleven top-level properties available to be created with the Statement API.

Figure 3. Top Level xAPI Statement Data Model. Adapted from ("xAPI Statement Data Model," n.d.).



The xAPI statement specifications list the following three requirements: a property cannot be used more than once per statement, each statement must include an actor, verb, and object property, and properties may appear in any order within the statement ("Advanced Distributed Learning Co-Laboratories," n.d., Statement properties section). Table 2 includes each xAPI statement property with its associated type of data, description, and statement inclusion requirements.

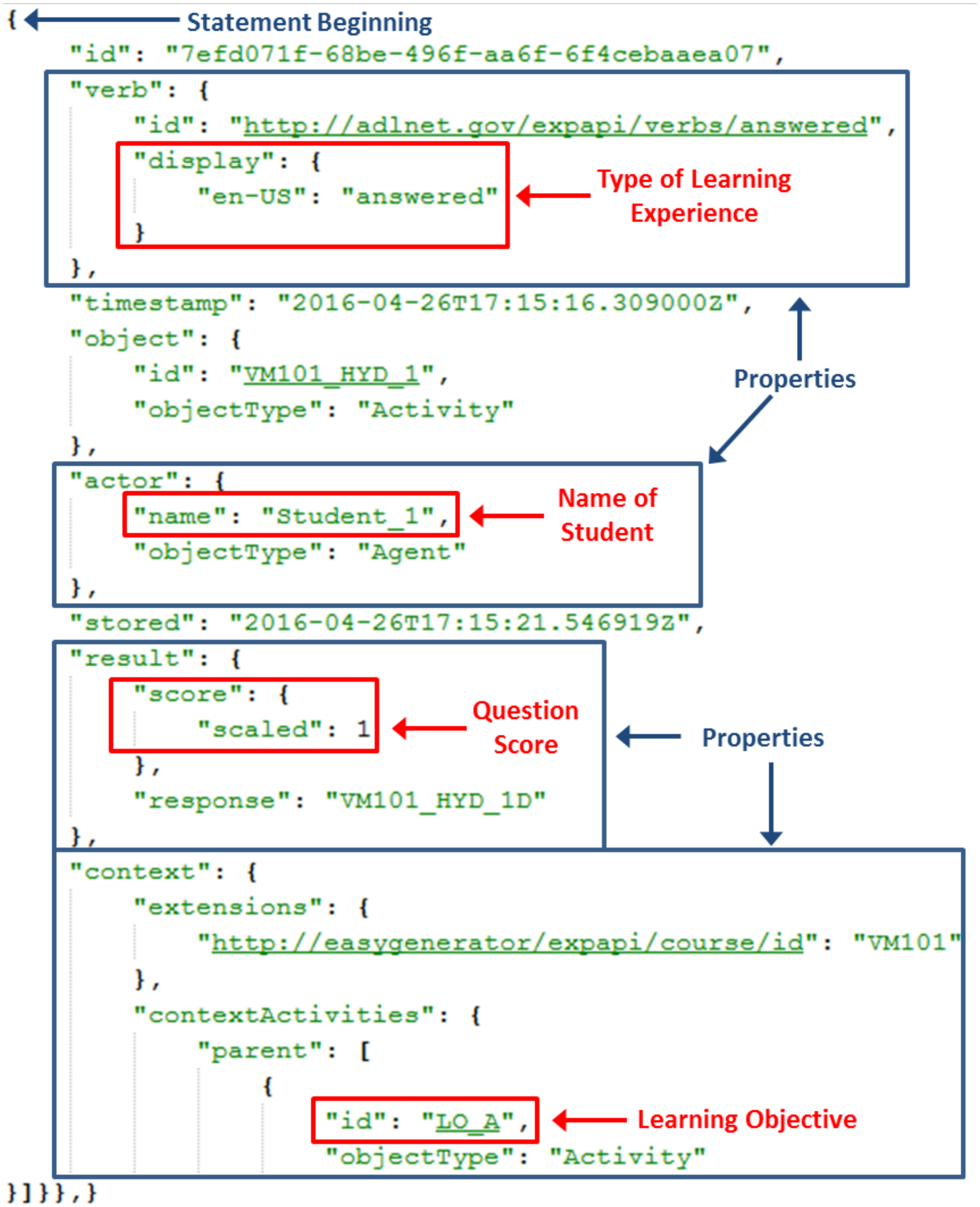
Table 2. xAPI Statement Properties. Adapted from ("Advanced Distributed Learning Co-Laboratories," n.d., Statement properties section).

Property	Type	Description	Required
id	Universally Unique Identifier (UUID)	UUID assigned by LRS if not set by the Activity Provider.	Recommended
actor	Object	Who the Statement is about, as an Agent or Group Object. Represents the "I" in "I Did This".	Required
verb	Object	Action of the Learner or Team Object. Represents the "Did" in "I Did This".	Required
object	Object	Activity, Agent, or another Statement that is the Object of the Statement. Represents the "This" in "I Did This". Note that Objects which are provided as a value for this field should include an "objectType" field. If not specified, the Object is assumed to be an Activity.	Required
result	Object	Result Object, further details representing a measured outcome relevant to the specified Verb.	Optional
context	Object	Context that gives the Statement more meaning. Examples: a team the Actor is working with, altitude at which a scenario was attempted in a flight simulator.	Optional
timestamp	Date/Time	Timestamp (Formatted according to ISO 8601) of when the events described within this Statement occurred. If not provided, LRS should set this to the value of "stored" time.	Optional
stored	Date/Time	Timestamp (Formatted according to ISO 8601) of when this Statement was recorded. Set by LRS.	Set by LRS
authority	Object	Agent who is asserting this Statement is true. Verified by the LRS based on authentication, and set by LRS if left blank.	Optional
version	Version	The Statement's associated xAPI version, formatted according to Semantic Versioning 1.0.0.	Not Recommended
attachments	Array of attachment Objects	Headers for attachments to the Statement	Optional

Aside from (potential or required) assignments of properties during LRS processing ("id," "authority," "stored," "timestamp," "version") Statements are immutable. Note that the content of Activities that are referenced in Statements is not considered part of the Statement itself. So while the Statement is immutable, the Activities referenced by that Statement are not. This means a deep serialization of a Statement into JSON will change if the referenced Activities change (see the Statement API's "format" parameter for details) ("Advanced Distributed Learning Co-Laboratories," n.d., Statement properties section).

Experience API provides the statement structure and definition which allows for statement storage ("Advanced Distributed Learning Co-Laboratories," n.d., Role of the Experience API section). The statement structure enables people and systems to conduct proper analysis of the collected data. Figure 4 is a sample learning experience captured in xAPI JSON statement format. The blue boxes depict individual properties and the red boxes depict examples of the types of data available for analysis. Each property's available contents and format will vary. A complete list may be found on the xAPI Statement Data Model located at https://drive.google.com/file/d/0BxhK5TH2EsphZFBXeVNnSGozWEE/view.

Figure 4. Captured Learning Experience in xAPI JSON Statement Format.



III. PROTOTYPE USE CASES FOR DEVELOPMENT

One way to determine learning effectiveness is to evaluate a student's performance of specific learning activities. To do this requires a two-step process. The first step in this process requires linking course assessments to course learning objectives. The second step requires assessing their level of learning by analyzing the student's performance in relation the course learning objectives. This thesis focuses on the first step of this process by creating a prototype system with the infrastructure and courseware capable of capturing and storing learning experiences as xAPI statements. The stored statements will contain the results of assessment questions and their associated learning objectives which can be used in determining individual learning objective performances values. Although this thesis does not cover the second step, it will show an example of data extraction from the repository and discuss possible future research in assessing the level of student learning.

Three use cases were developed to demonstrate linking course assessments to course learning objectives. The first use case covers course structure and the process to create an online course. The second use case covers the technologies (LMS, LRS, xAPI) used to capture and store assessment statements. The third use case covers the extraction of data from the repository. Since e-learning courses on MarineNet are typically self-paced courses with automated multiple choice assessments, the courseware structure and assessments created for the prototype system are limited in scope to those types of courses. For background purposes only, the use cases cover some concepts outside of multiple choice assessments.

A. STAKEHOLDERS

The use cases cover the following stakeholder groups: students, course instructors, and course developers. Table 3 depicts each stakeholder with their associated tasks. This thesis refers to the course instructor and developer as separate individuals with separate tasks but they can the same person in a real educational setting. A fourth stakeholder group, institutional administrators, is listed in Table 3, but is only referenced briefly in Use Case 3, Chapter IV, and Chapter V.

Table 3. Stakeholders and Their Tasks.

Stakeholder	Tasks
Student	• request enrollment in course on LMS • take course and assessments
Course Instructor	• compile course learning objectives • create content and assessments that will support those learning objectives • identify course performance data to be captured and stored • enroll or approve enrollment request of student in course on LMS • analyze results of student learning objective performances
Course Developer	• develop course on an LMS given course content and structure from course instructor • create repository for performance data to be stored on • ensure course performance data is captured and stored • extract results of student learning objective performances for analysis by instructors
Institutional Administrators	• identification of courses and their goals to support curriculum • analyze results of student learning objective performances to evaluate course effectiveness in curriculum objectives • analyze results of student learning objective performances to evaluate instructor effectiveness in course and curriculum objectives

B. USE CASE 1—COURSWARE CREATION

The Eberly Center at Carnegie Mellon University states that course assessments should capture the amount a student has learned, and for this to occur the following three components must be aligned: learning objectives, instructional strategies, and assessments (“Why should assessments,” n.d.). They also define instructional strategy as the activities that will reinforce learning activities and prepare students for assessments (“Why should assessments,” n.d.). The instructional strategy used in the use cases and prototype system courseware will deliver self-paced course content with automated multiple choice assessments. This strategy closely models the structure of current MarineNet courses offered.

The actors in Use Case 1 are the course instructor and developer. Use Case 1 assumes an instructor has received a course goal which establishes the overall purpose and outcome of the course. The instructor’s first step after assessing the course goal is to create the course learning objectives. The second step creates assessment questions that properly evaluate a student’s knowledge for the individual course learning objectives. The instructor’s last step creates structured content that support the learning objectives and assessment questions. Lastly, the course developer takes the completed course content and structure, and publishes the course in a format compatible with the LMS.

1. Learning Objectives

Learning objectives are statements that clearly convey what a student should learn, or task they should be able to complete after a given period of instruction. Learning objectives are important to a course’s development and structure because ensure all aspects of the course goal are met while providing organization and direction for the intended course topics. According the Office of Distance Learning at Florida State University, instructors should create learning objectives that provide a clear understanding of the desired learning outcomes without focusing on the form of instruction, and also be focused on student performance (2011). The following are several key characteristics all learning objectives should have: specific, measurable, attainable, relevant, and targeted at the student.

Three main components of learning objectives are person, verb, and conditions. The person component is who the learning objective is intended for, typically “the student.” The verb component is the action the person is to accomplish. The conditions component are the circumstances the person conducts the verb actions. The following are examples of complete learning objectives.

- Given a diagram of a passenger vehicle, the student locates the five major hydraulic brake components of a passenger vehicle.
- Without the aid of reference, the student describes the purpose of a vehicle’s steering system.

2. Course Assessments

A course assessment is a tool used by the instructor to determine the learning objective performance of a student. The Eberly Center recommends instructors take the following into consideration when creating assessment questions: selection of an appropriate question type to match the learning objective, point value of questions, time allotted for assessment, and having a third party review questions (“Creating Exams,” n.d.). Instructors also need to ensure the content and scope of every question in the assessment directly relates to a course learning objective.

A few question types that can be asked in assessments are multiple-choice, essay, short answer, and matching. It is important the question type supports the verb in the learning objective. If a learning objective’s verb is to “explain” then an appropriate question type to evaluate the student’s performance would be an essay or short answer, not a multiple-choice. The question type needs consideration when assigning point values, quantity and type of questions, and amount of time allotted. Essay and short answer questions typically take longer for a student to respond to than matching questions. Lastly, it is important for third party review of the assessments to ensure question and answer clarity and scope. Since this thesis’ focus is multiple choice assessments, all prototype courseware learning objectives are supported by this type of question.

When creating course assessments, instructors must ensure each learning objective is represented in the assessment by the minimum number of questions needed to assure a proper evaluation of performance. Typically, multiple assessment questions are asked to ensure the learning objective is properly assessed. In a case where a course goal requires a high number of learning objectives or assessment questions to evaluate a student's performance, the use of in-course quizzes, standard EOC exams, or a combination of both can be used. This technique to distribute questions throughout a course can ensure the adequate evaluation of all learning objective performances while maintaining practical quiz and EOC exam lengths.

3. Course Content and Structure

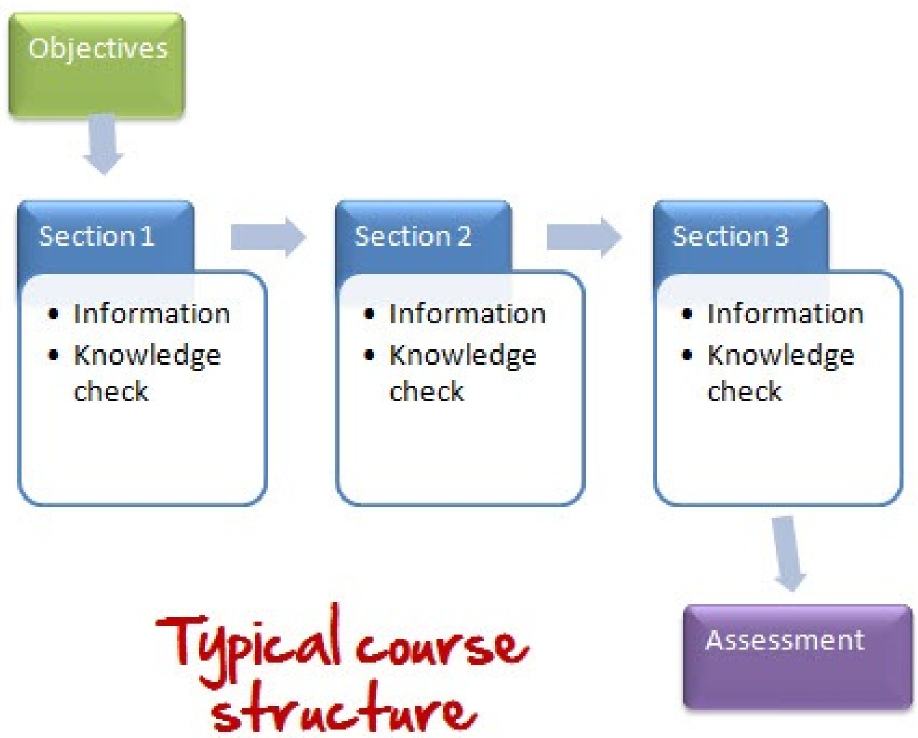
Course instructors can choose from many different types of content when deciding how best to support the course learning objectives and assessments. Types of content can include: multimedia, tables, images, documents, and plain text. Table 4 provides the Center for Advanced Teaching and Learning at the University of Wisconsin La Crosse's popular ways of presenting content.

Table 4. Popular Content Presentation Types. Adapted from "Ways to present content" (n.d.).

Presentation Type	Content Type	Characteristics
Video and Audio	Multimedia Tables Images	• good for demonstrations • time consuming • best if accompanied with text version
Portable Document Format (PDF)	Tables Images Text Documents	• maintains formatting on all devices • downloadable, printable • presents text with accompanied images well
Slides (PowerPoint)	Tables Images Text	• consider accompanying with audio
website Links	Tables Images Text Documents Multimedia	• provides access to other presentation methods • access to articles, textbooks, case studies • requires Internet connection

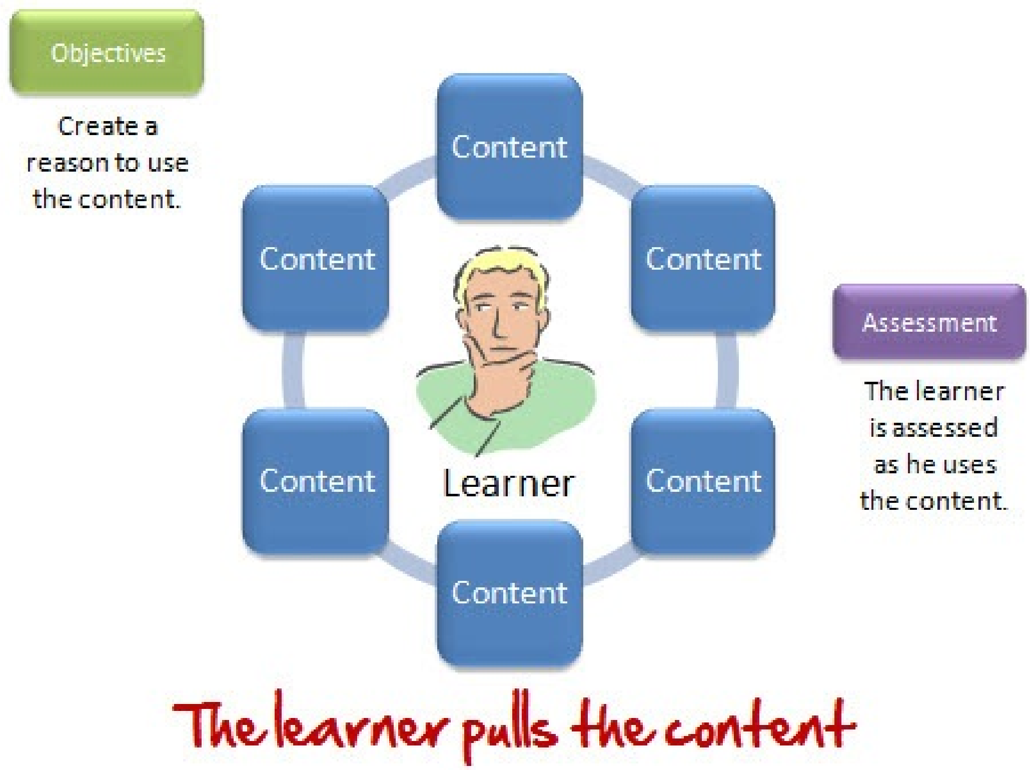
Two methods to structure and deliver the course content are push and pull. The push method delivers course content in a sequential order determined by the course instructor and requires students to access all content in the prior sections/modules prior to moving on to the next (see Figure 5). This method is useful for instructors to ensure content is accessed in a particular order, ensuring compliance of content access, and for ensuring all students receive the same course experience.

Figure 5. Push Method of Course Content Delivery. Adapted from Kuhlmann (2009).



The pull method of delivering course content allows access to all course content and relies on the student to seek out the information they feel they need to accomplish the course learning objectives (see Figure 6). This method allows each student to customize their own learning experiences and creates a more efficient use of time and resources. The pull method does not negate the need to conduct an assessment to determine learning objective performances, it just enables students to focus their educational efforts on the content they assess they need based on previous knowledge and experience.

Figure 6. Pull Method of Course Content Delivery. Adapted from Kuhlmann (2009).



4. Publishing a Course

In the context of e-learning, publishing a course has a few different meanings. For the purpose of this thesis, publishing a course will be the act of creating a SCORM 1.2 or 2004 compliant course package using the instructor provided course elements (learning objectives, assessments, and content). According to the former President of Rustici Software Mike Rustici, the SCORM compliant package is typically a ZIP file type containing all the files and folders needed to deliver the course and is referred to as a package interchange file (PIF) (2009). The PIF is what allows a SCORM compliant course to be loaded on to any LMS capable of supporting that version of SCORM.

The course developer typically uses course generator or authoring tool software to upload and structure the elements of the course into the instructor's desired format. Once this is complete, the course developer will select the required version of SCORM and use the software to publish the course. According to Rustici, when publishing a course the software creates and places into the PIF, the manifest file, Shareable Content Objects (SCOs), assets, and other SCORM required support files (2009). A SCO is a unit of instruction that contains one or files that communicates with the LMS and an asset is collection of one or more static content files that is presented to the student but does not communicate with the LMS (2009). Rustici also states, the manifest file is an eXtensible Markup Language (XML) file that describes all the content in the PIF to include the SCOs and assets, and must exist at the root (2009). It is important for the developer to verify the versions of SCORM the LMS is capable of supporting prior to publishing to ensure the course will be compatible with the desired system.

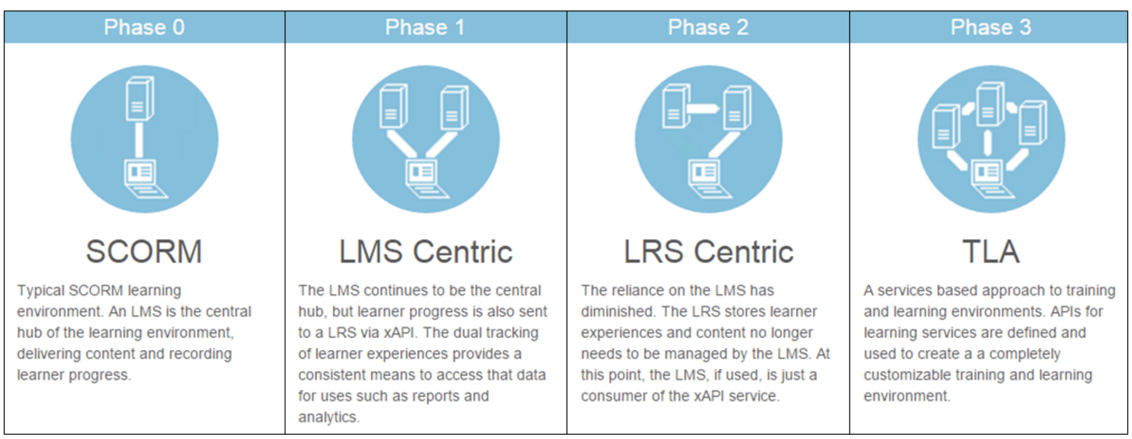
Experience API can be incorporated into a SCORM compliant course before or after a developer publishes the course. Some course generation software have the ability to select preset experience statements to capture and designate a LRS to which to store them on. These statements can include the following: when a course or module is started or stopped, whether a student passed or failed the course or module, and whether a student answered a question correctly or not. If the developer selects these options prior to publishing a course the xAPI statement code and associated JavaScript files will be created and included in the PIF. Incorporating xAPI into a PIF is possible by manually creating JavaScript files and entering xAPI statement code into existing files. Whether incorporating xAPI by using course generation software or manual input, it is important to include the correct LRS endpoint (LRS location) and authentication credentials to ensure the statements are stored properly. This method can be time consuming and requires a very detailed knowledge of SCORM and xAPI.

C. USE CASE 2—CAPTURE AND STORAGE OF ASSESSMENTS

Use Case 2 discusses the implementation of xAPI on a LMS only learning architecture, the administrative setup of the course PIF on the LMS course, the setup of the LRS, and how a student's interaction with a course creates and stores xAPI statements. The actors for Use Case 2 consist of the course developer who administratively sets up the LMS course and uploads the courseware PIFs, the instructor who verifies the course represents the desired elements and structure as well as enrolls the student, and the student who accesses the course and assessments.

ADL has developed the SCORM-to-TLA (Training and Learning Architecture) Roadmap which is a four phased approach for transitioning from a LMS only structure to a TLA ("SCORM to TLA Roadmap," n.d.). Figure 7 is a graphical depiction of ADL's SCORM-to-TLA Roadmap with descriptions of the four phases. With CDET's MarineNet architecture currently in the SCORM phase (Phase 0), this use case and the prototype system will only discuss the setup and use of the LMS Centric phase (Phase 1).

Figure 7. ADL's SCORM-to-TLA Roadmap. Adapted from "SCORM to TLA Roadmap" (n.d.).



The LMS Centric phase uses the idea of "dual-tracking" which maintains the LMS as the center of the learning architecture as in the SCORM phase, but implements xAPI into the SCORM compliant course to add the ability to track learning experiences on a LRS ("LMS Centric," n.d.). ADL also states that the LMS Centric phase has the benefit of allowing an organization to protect and maintain its existing e-learning/SCORM knowledge and architecture, while providing the ability to track learning experiences a LMS is incapable of tracking ("LMS Centric," n.d.). Implementing a LMS Centric architecture allows an organization to phase in the use of xAPI over time by allowing them to update as many or as few courses as the course developers can handle. This would allow CDET to incrementally update their courseware to include xAPI without disrupting MarineNet's current course completion tracking while meeting their goal of finding ways to improve the level of e-learning they are providing students.

1. LMS

Three roles users can be assigned on a LMS are student, instructor, and administrator. Most LMS have the ability to customize the permissions for each of user or user role. To not cause confusion between institution administrators and the role of a LMS administrator, this use case will assume the course developer has been assigned the role of LMS administrator.

For a course developer to upload a PIF to a LMS, a LMS course must first be administratively established. This allows the assignment of users to instructor and student roles of the course, enrollment/disenrollment, course status, tracking to the LMS only, dates of course availability, and the upload of content to include the PIF. Once the course developer uploads the PIF and verifies the SCORM compliant course is running properly on the LMS, a course instructor can be assigned and student enrolled.

2. LRS

Storing xAPI statements to an LRS requires established credentials within the administrative settings of the LRS. Two types of credentials used for LRSs are Hypertext Transfer Protocol (HTTP) Basic Authentication and OAuth 2.0. HTTP Basic Authentication is a method of authentication that requires the user to send the LRS' credentials (user name and password) in the clear over the Internet. This provides no confidentiality of the credentials and poses a security risk. Request for Comments (RFC) 6749 created by the Internet Engineering Task Force, states that OAuth 2.0 provides a more secure means of accessing LRS data because the user no longer uses the LRS' credential and instead is issued an access token which specifies the scope, lifetime, and other access attributes (Internet Engineering Task Force, 2012). Figure 8 shows the interaction between the client (user) and resource server (LRS).

Figure 8. OAuth 2.0 Abstract Protocol Flow. Source: Internet Engineering Task Force (2012).

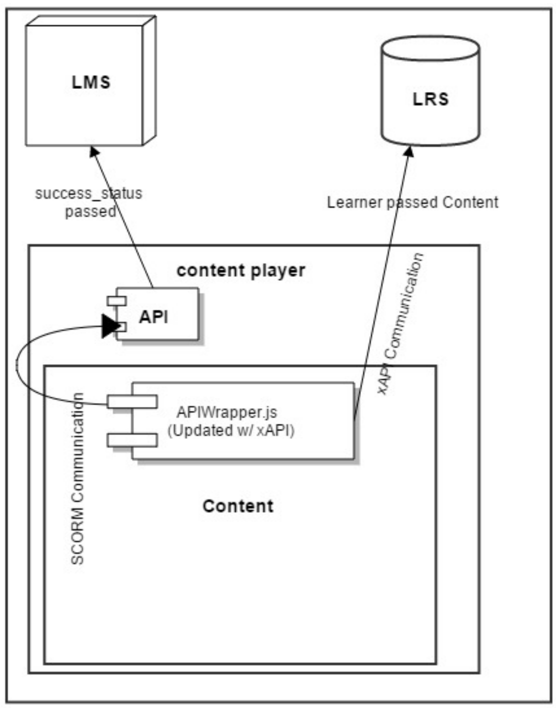
```
+--------+                               +---------------+
|        |--(A)- Authorization Request ->|   Resource    |
|        |                               |     Owner     |
|        |<-(B)-- Authorization Grant ---|               |
|        |                               +---------------+
|        |
|        |                               +---------------+
|        |--(C)-- Authorization Grant -->| Authorization |
| Client |                               |     Server    |
|        |<-(D)----- Access Token -------|               |
|        |                               +---------------+
|        |
|        |                               +---------------+
|        |--(E)----- Access Token ------>|    Resource   |
|        |                               |     Server    |
|        |<-(F)--- Protected Resource ---|               |
+--------+                               +---------------+
```

Similar to an LMS, an LRS usually has the ability to assign users varying roles or levels of permission. These permissions allow the statements stored to the LRS to be accessed and viewed only by authorized individuals. They can also be used to control the export of statements off the LRS to other systems capable to using them in further analysis.

3. Dual Tracking with xAPI

Dual tracking of data in the LMS Centric phase requires the ability to communicate data to both the LMS and LRS (Poltrack & Creighton, 2015). Figure 9 depicts the communication relationships between the LMS, LRS, and the SCORM course with xAPI in a dual tracking configuration. According to Poltrack and Creighton's paper, requested content containing xAPI JavaScript code is sent by the LMS accompanied by a content player consisting of a SCORM API which facilitates the communication of data between the LMS and content (2015). When the content is ready to send data to the LMS it makes Initialize() and SetValue() calls to the SCORM API while simultaneously calling functions within the JavaScript code (APIWrapper.js in Figure 9) (Poltrack & Creighton, 2015).The JavaScript code create and transmit JSON statements to the LRS using abstracted SCO tracked data. Although xAPI code extracting SCO tracked data can be created manually, ADL developed JavaScript files (i.e., APIWrapper.js, xapiwrapper.min.js, SCORMToXAPIFunctions.js) to take some coding complexities out of determining the LMS interface calls needed for the abstraction, creation, and transmission of data to the LRS (Poltrack & Creighton, 2015).

Figure 9. SCORM Course with "Dual Tracking" to LMS and LRS. Source: Jonathan Poltrack, personal communication, March 14, 2016.



D. USE CASE 3—EXTRACTION OF DATA

Use Case 3 discusses the extraction of data collected from the learning experiences captured within SCORM courseware integrating xAPI. The actors for Use Case 3 are students, course instructors, course developers, and institutional administrators. Depending on the types of data collected and stored in the LRS, all actors might have an interest in accessing various parts of the stored statements. The following are examples of uses various stakeholders might want to access the statements for.

- Students—determine their own performance and trends over a subject or curriculum
- Course instructors—gather learning information about current and future students to customize the courses they deliver in order to provide a more effective learning environment
- Course developers—determine new uses of the current data collected as well as determine new useful data to collect
- Institutional administrators—determine trends in student and instructor performance at the course and curriculum level

Three ways to extract data from an LRS are pulling the data off the LRS, pushing the data out of the LRS to a system capable of accepting it, and exporting the captured JSON statements to CSV files. This prototype system exports captured JSON statements to CSV files due to the universal nature of the CSV file format to be accepted on a wide range of systems to include analytic software and databases.

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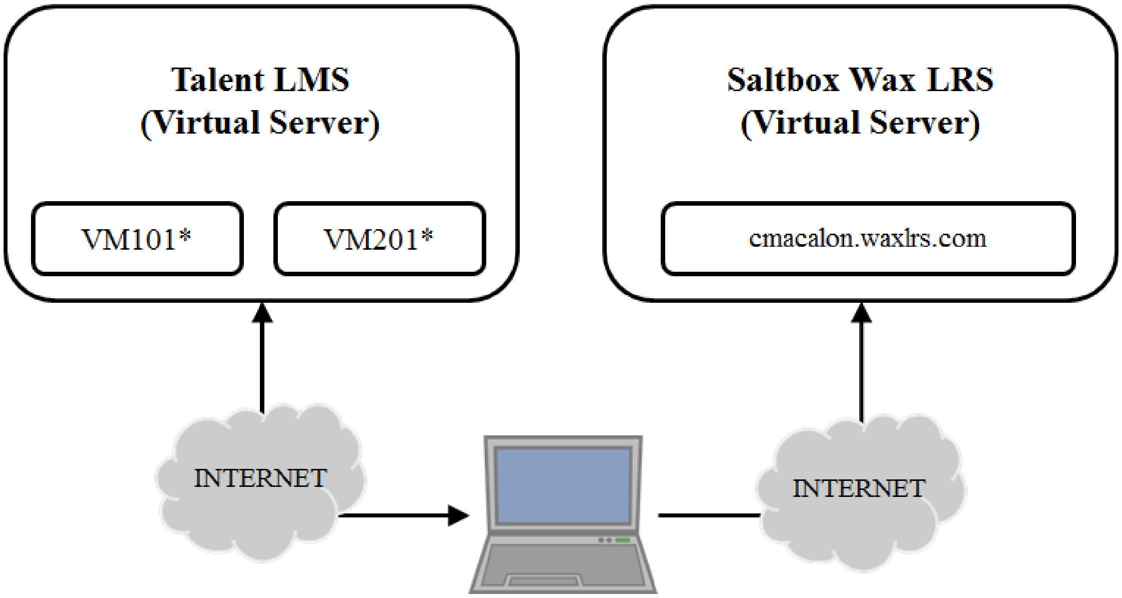
IV. PROTOTYPE SYSTEM IMPLEMENTATION

The purpose of the prototype system is to demonstrate the capture and storage of student learning experiences in JSON format using xAPI in a LMS Centric/dual-track architecture. The following three high-level tasks were required to develop the prototype system: creation of a LRS with credentials to store the JSON statements, creation of SCORM compliant courseware, and the creation of a LMS to administer the courseware. The prototype system enables a collective analysis of individual learning experience statements allowing learning objective proficiencies to be calculated into a student's learning objective performance value. This learning objective performance value can then be used in further analysis by educators to make a more detailed assessment as to the level of learning a student has attained in a given subject.

A. PROTOTYPE ARCHITECTURE

The prototype system uses a LMS Centric/dual-track architecture which requires a LMS, LRS, SCORM compliant course configured with xAPI, and a student device with web browser. Figure 10 depicts the prototype dual-track architecture as well as the third-party vendors used to provide the required services. The prototype system uses Talent LMS to manage the administrative tasks of managing user roles, hosting of the SCORM courseware (VM101—Passenger Vehicle Maintenance Course, VM201—Commercial Vehicle Maintenance Course), and providing SCORM content to the student's device. Saltbox Wax LRS is used to receive and store the JSON statements created on the student's device through the interaction with the SCORM courseware. Since this architecture is using third-party vendors to provide services, it assumes continuous Internet connectivity between the student's device and LMS to allow content, assessments, and course results to be communicated back and forth. Internet connectivity between the student's device and LRS is only required during the transmission of JSON statements to the LRS.

Figure 10. Prototype System Architecture.



*VM101 and VM201 are SCORM-compliant courses with xAPI created using easygenerator.com and uploaded to Talent LMS for course hosting.

B. VENDOR SERVICES

Three SaaS vendors were used to create the prototype system. The vendors were selected based on their services meeting the requirements needed to establish a dual-track architecture. Table 5 provides a list of the third-party vendors and their services used in the creation of the prototype system.

Table 5. Third-Party Vendors and Services Provided/Utilized.

Vendor	Service Plan	Services Provided/Utilized
Easygenerator	Plus ($39.99 / mo)	• learning objective creation • course delivery layout creation (pull method used) • integration of xAPI • quiz and exam question creation (single choice answer only used) • publish prototype course in SCORM 1.2 • publish prototype course to Easygenerator web server (testing only) • create up to 100 courses or exams (2x courses, 2x exams created)
Talent LMS	Free (free)	• 5 user limit (4 users created) • 10 course limit (2 courses hosed) • ability to assign administrator, instructor, and student roles • manage assignment of instructors and enrollment of students • assignment of courses to categories • ability to upload multiple content formats to created courses (only SCORM w/ xAPI uploaded) • manage student's course completion status
Saltbox Wax LRS	Explore (free)	• 2,000 JSON statement limit per month • ability to access created JSON statements • ability to create Basic and OAuth credentials

C. COMPONENTS

1. Courseware

Creating the prototype courseware required a two-step process. The first step developed the course elements (learning objectives, assessments, and content). The second step created a SCORM PIF with xAPI capable of extracting JSON statements to the designated LRS using the course elements. The courseware PIFs were then be uploaded to an LMS allowing users to administer and interact with the courses.

a. Learning Objective, Assessments, Content

The prototype courseware consists of one curriculum program with two individual courses. Each course has four modules with quizzes and contains an EOC exam. Each module is linked to one learning objective and provides the student course content and two quiz questions directly relating to that learning objective. The EOC exam consists of two questions per learning objective for a total of eight questions. Table 6 outlines each course, its learning objective, and parent subject of each learning object. The full course outline including all modules, learning objectives, content, and quiz and exam assessment questions with all possible answers can be referenced in Appendix A.

Table 6. Prototype Courseware Learning Objectives and Parent Subject.

Course	Parent Subject	Learning Objectives
VM101	Brakes	**Learning Objective (A)**—Without the aid of reference, recall the major components of a vehicle's hydraulic brake system and their purpose.
	Electrical	**Learning Objective (B)**—Without the aid of reference, recall the major components of a vehicle electrical system and their purpose.
	Steering	**Learning Objective (C)**—Without the aid of reference, recall the major components of a vehicle's steering system and their purpose.
	Engines	**Learning Objective (D)**—Without the aid of reference, recall the major components of a gasoline engine and their purpose.
VM201	Brakes	**Learning Objective (E)**—Without the aid of reference, recall the major components of a vehicle's air brake system and their purpose.
	Electrical	**Learning Objective (B)**—Without the aid of reference, recall the major components of a vehicle electrical system and their purpose.
	Steering	**Learning Objective (C)**—Without the aid of reference, recall the major components of a vehicle's steering system and their purpose.
	Engines	**Learning Objective (F)**—Without the aid of reference, recall the major components of a diesel engine and their purpose.

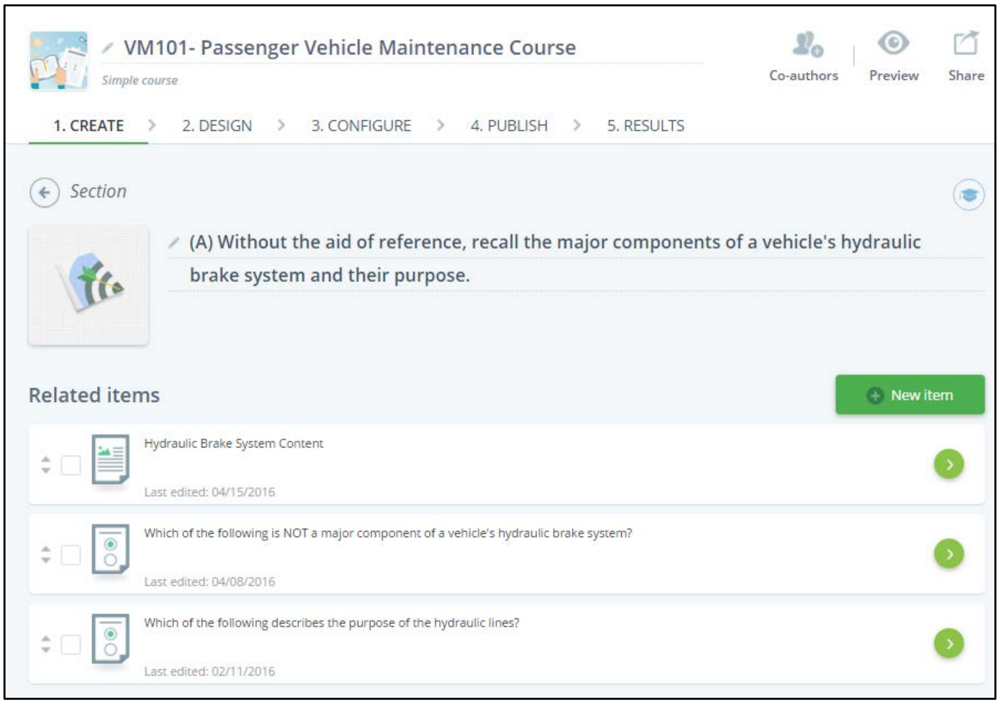
Curriculum—Vehicle Maintenance, VM101—Passenger Vehicle Maintenance Course, VM201—Commercial Vehicle Maintenance Course.

The two prototype courses have shared learning objectives (B and C) and similar learning objectives (A and E, D and F) that are subsets of a parent subject in order to emphasize the possible relationships between different courses within a curriculum. These relationships along with scores of the individual learning objective questions are used in the analysis of the JSON statements and the calculation of the learning objective performance value.

b. Publishing SCORM PIF

The SCORM PIFs in the prototype courseware were published in SCORM 1.2 format using the services provided at Easygenerator.com. Each course consists of two PIFs. The first PIF contains the modules with associated learning objectives while the second PIF contains the EOC exam questions and associated learning objectives. Each module (referred to as sections in Easygenerator.com) contains the content and quiz questions associated with only one learning objective. Figure 11 depicts VM101's Hydraulic Brake System Module's content, two quiz questions, and linked learning objective. The remaining modules in both courses are structured the same as Figure 11. The EOC exams for both courses are structured the same as Figure 11 without the content item.

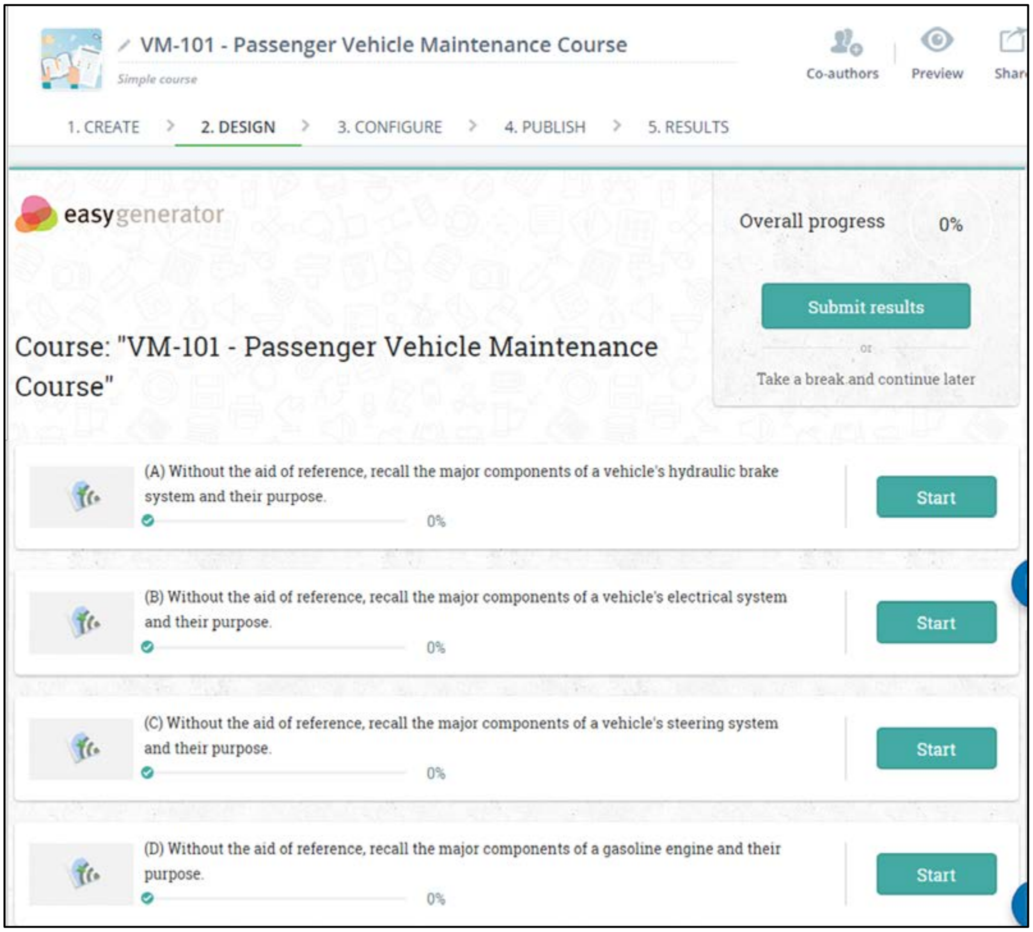
Figure 11. Easygenerator.com Course Generator Software Module/Learning Object Example.



Example of the courseware's module layout linking of the learning objective to content and quiz questions. Screenshot from http://live.easygenerator.com/#courses/ee912cd399f8463a8b088cdf77785a77/sections/c0146111171b4d62ba835ca91ea3e25c.

The prototype courseware uses a pull content delivery method which allows the student to complete the modules and learning objectives in the order they feel best supports their learning. Figure 12 depicts VM101's design layout using the pull content delivery method.

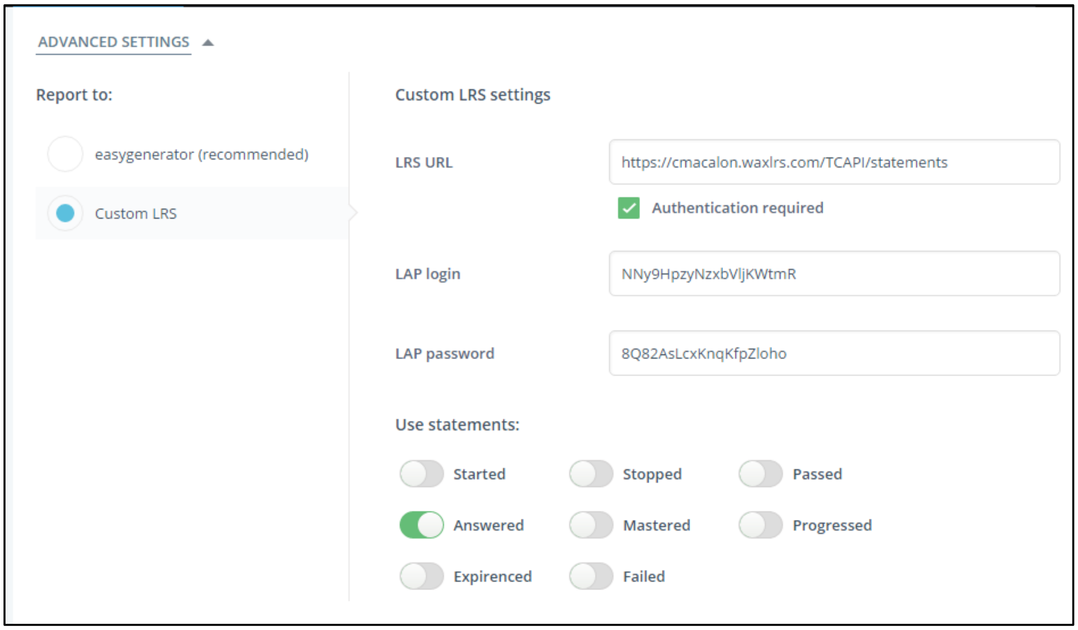
Figure 12. Easygenerator.com Course Generator Software Content Delivery.



Example of the courseware's pull content delivery method setup and design allowing a student to "Start" the module of their choice. Screenshot from http://live.easygenerator.com/#courses/ee912cd399f8463a8b088cdf77785a77/design.

The prototype courseware uses xAPI to capture and transmit to the LRS how a student answered a question and whether they passed or failed the EOC exam. An xAPI JSON statement is created for every quiz and exam question a student submits, and at the completion of an exam. Figure 13 depicts Easygenerator.com's LRS configuration page requiring a LRS Uniform Resource Locator (URL), login with password (credentials), and requested experience statements. The actions the courseware PIFs track are answered statements (individual question results) for quiz questions in modules, and answered and passed/failed statements (percentage of exam questions correct or incorrect) are tracked in EOC exams. The prototype courseware uses a percentage value of 75% to determine EOC passed/failed statements.

Figure 13. Easygenerator.com Course Generator Software xAPI Tracking Settings.



Example of the courseware's LRS configuration settings. Screenshot from http://live.easygenerator.com/#courses/ee912cd399f8463a8b088cdf77785a77/configure.

When publishing the prototype courseware PIFs, Easygenerator.com's software assigns unique identification numbers in the form of 16-byte hexadecimal values to each course title, module title, learning objective, quiz and exam question, and each answer option to the questions. These identification numbers are used in the answered and passed/failed JSON statements sent to the LRS. The identification number assignments are saved as objects within a JavaScript file (data.js) contained in the PIF. Since each PIF was published individually, the same learning objective was assigned multiple unique identification numbers when appearing in multiple PIFs. Each learning objective appears in a minimum of two PIFs, a module and EOC exam PIF. Learning objective B and C appear in all four PIFs since they are found in both VM101 and VM201 (see Table 6, Prototype Courseware Learning Objectives and Parent Subject).

To ensure the JSON statements stored in the LRS can be grouped by course and learning objective, each course title and learning objective unique identification number within the courseware were modified to facilitate the determination of a student's learning objective performance value. Also, to make the JSON statements easier to read and understand, as well as demonstrate the ability to customize the xAPI statements, the module titles, questions, and answer identification numbers were modified to a user-friendly naming convention. Table 7 uses VM101's Hydraulic Brake Module to demonstrate naming convention used throughout the courseware data.js files.

Table 7. Courseware Identification Renaming Convention.

Element	**Title**	**Renamed Identification**
Course Name	Passenger Vehicle Maintenance Course	VM101
Learning Objective	(A) Without the aid of reference, recall the major components of a vehicle's hydraulic brake system and their purpose.	LO_A
Module Name	Hydraulic Brake System Module	VM101_HYD
First Question of Module	Which of the following is NOT a major component of a vehicle's hydraulic brake system?	VM101_HYD_1
Answer choice (a) to Question 1	brake pedal	VM101_HYD_1A

c. xAPI Statement Properties

The xAPI statements created by the prototype courseware contain the same structure and objects that can be found in Figure 3 (Chapter II—Top Level xAPI Statement Data Model) except version and attachment properties. Tables 8 and 9 provide complete lists of properties found in the two types of xAPI statements the courseware creates, answered and passed/failed respectively. The primary difference between the two statements types is that the individual question properties (object.definition) can be found in the answered statements. Since answered statements are created by a student's submission of an answer to a question, all applicable question properties are added to the xAPI statement. The passed/failed statement will not contain these properties as this statement is only created at the submission and scoring of an entire exam.

Table 8. Prototype xAPI Answered Statement Properties with Description.

Property Elements	Description
verb.id	Identification of action statements
verb.display	Title of action statements (answered)
timestamp	Date and time statement was created
object.definition.choices.id	Identification of question's answer choice
object.definition.choices.description	Title of question's answer choice
object.definition.correctResponsesPattern	Identification of question's correct response
object.definition.type	Type of SCORM interaction extracted to xAPI
object.definition.name	Question text
object.definition.interactionType	Question type
object.id	Identification of question
object.objectType	Object type of the question
actor.mbox	Email address of the student
actor.name	Name of the student
actor.objectType	Object type of student
stored	Date and time statement is stored to LRS
result.score.scaled	Numerical value of response Answered = 0 or 1
result.response	Students response to question
context.registration	Unique identification given all context in a course
context.extensions.http://easygenerator/expapi/course/id	Identification of Course
context.contextActivities.parent.definition.name	Text of learning objective
context.contextActivities.parent.id	Identification of learning objective
context.contextActivities.parent.objectType	Object type of learning objective
id	Unique identification give to statement
authority.account.homePage	URL of LRS
authority.account.name	Username of account on LRS
authority.objectType	Object type account

Table 9. Prototype xAPI Passed/Failed Statement Properties with Description.

Property Elements	Description
verb.id	Identification of action statements
verb.display	Title of action statements (passed or failed)
object.definition.name	Title of Exam
object.id	Identification of exam title
object.objectType	Object type of the exam
actor.mbox	Email address of the student
actor.name	Name of the student
actor.objectType	Object type of student
stored	Date and time statement is stored to LRS
result.score.scaled	Numerical value of response Passed/Failed = 0 through 1 (decimal value for SCORM 1.2)
context.registration	Unique identification given all context in a course
context.extensions.http://easygenerator/expapi/course/id	Identification of Course
id	Unique identification give to statement
authority.account.homePage	URL of LRS
authority.account.name	Username of account on LRS
authority.objectType	Object type account

2. LMS Configuration

The prototype system uses a cloud based LMS provided by TalentLMS to manage the courseware administration and delivery. Configuring the prototype LMS consists of the creation of users and their roles, a curriculum, and courses. For the purpose of this thesis an LMS course is defined as the administrative object on an LMS to which users are assigned, course completion within the LMS tracked, the location courseware PIFs are uploaded to, and where the PIF launch settings are configured.

a. LMS Users

Four users were created and assigned one of three user roles within the LMS providing them varying levels of permissions to conduct their required actions. The administrator user role allows a user to create and delete users, user types, courses, assignment of instructors, and manage all administrative settings within the LMS. The instructor user role allows a user to add courses and content, enroll students, and view course completion status and results. The student user role allows a student to request enrollment in a course and take a course. Table 10 provides a complete list of users, user role assigned, and actions conducted.

Table 10. LMS Users and Actions.

User	LMS User Role	Actions
Course Developer	Administrator	• Create users • Create curriculum Vehicle Maintenance • Create courses VM101 and VM201 • Assign Instructor
Course Instructor	Instructor	• Upload courseware PIFs • Enroll Student_1 and Student_2 in both VM101 and VM201 • Track student course completion
Student_1	Learner	• Take VM101 and VM201 courses
Student_2	Learner	• Take VM101 and VM201 courses

b. Curriculum and Courses

The course category Vehicle Maintenance was created to maintain organization within the LMS, simulate a larger overarching course catalog, and act as a curriculum of courses a student must complete. The LMS courses VM101 and VM201 were created within the Vehicle Maintenance category and the courseware PIFs were uploaded as SCORM content to their respective LMS courses. Each LMS course contains a module/quiz PIF and an EOC exam PIF. PIF launch settings within the LMS course are set to enforce that only the EOC exam must be taken in order for LMS course completion. The setting not requiring the module/quiz PIF to be completed allows a student the option to proceed directly to the EOC exam if they feel their knowledge in the learning objectives is sufficient enough to meet the standards assigned by the course instructor.

3. LRS Configuration

The configuration of the prototype system's LRS consists of establishment of a LRS URL and a single set of basic credentials. Only one set of LRS credentials are required in the prototype system because both VM101 and VM201 courses are instructed by the same individual.

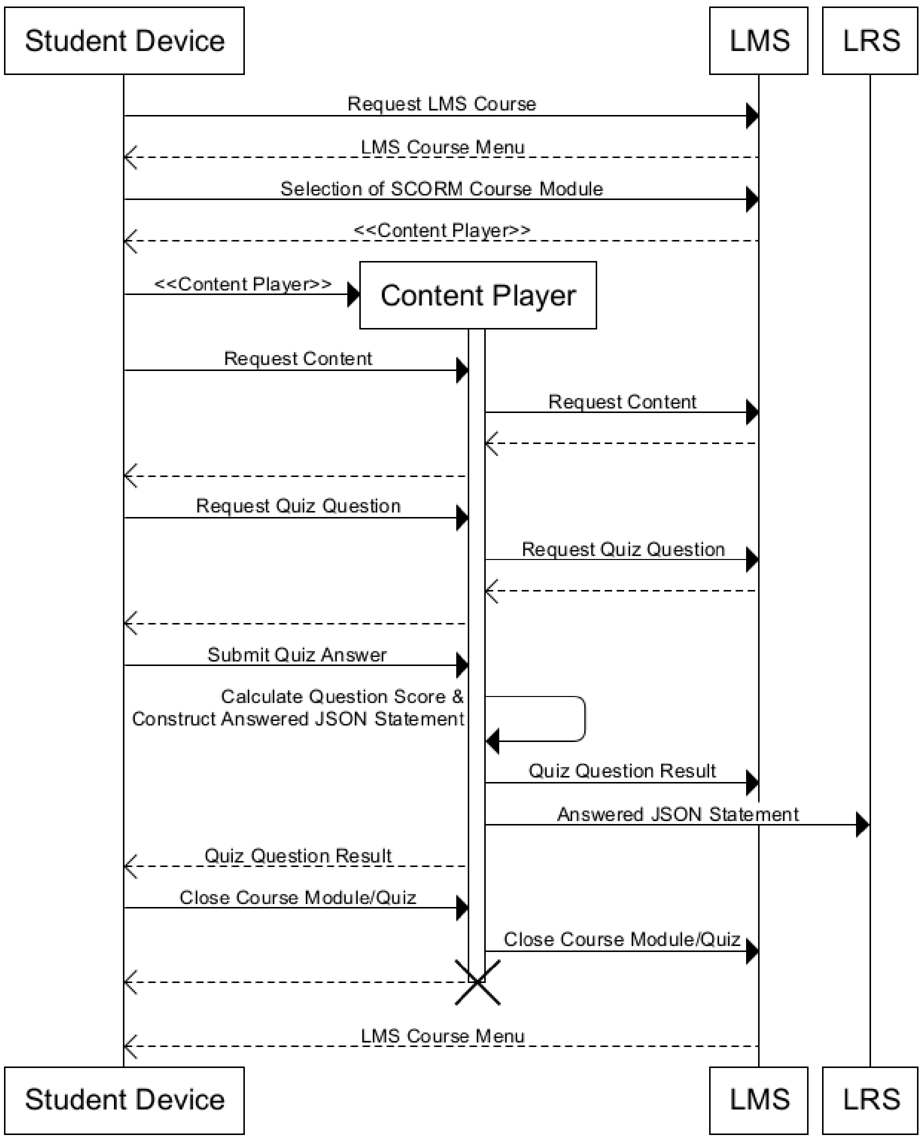
D. SEQUENCE DIAGRAMS

The complete prototype system with its courseware produces and transmits xAPI statements during student's interaction with the module/quiz and EOC Exam. In both the module/quiz and EOC Exam, a student device with Internet browser is required in order for the courseware to be launched and viewed, answers to questions submitted, and xAPI statements transmitted to the LRS. Since the LMS course contains both the module/quiz and EOC exam the student device-to-LMS interaction to launch either is identical. The module/quiz and EOC exam differ in timing of the construction, submission, and transmission of xAPI statements to the LRS. Figures 14 and 15 are sequence diagrams for a student taking the module/quiz or EOC exam and both assume the student is a logged into the LMS and enrolled in the LMS course.

1. Module with Quiz Submission

As shown in Figure 14, the student device requests (HTTP get) the LMS course from the LMS which replies (HTTP post) with the menu allowing the student to select the module/quiz (HTTP get). The LMS responds to the selection the module/quiz by sending the content player for initialization on the student device (see Figure 9 in Chapter II, Section C for detailed explanation of the content player). With the content player initialized on student device, all requests and replies for content (HTML) and quiz questions (HTML/JavaScript) occur through the content player. The module/quiz displays one question at a time for submission. When the student device submits a quiz answer to the content player, the content player calculates the question score and constructs an answered xAPI statement in JSON format with the properties found in Table 8. The content player then sends the LMS the question result and the LRS the constructed answered xAPI statement. The process of requesting content and quiz question will continue until the request by the student device to close the module/quiz. The closure request is sent to through the content player to the LMS at which time the content player is deconstructed and deleted from the student device. The final step in the process consists of the LMS sending to the student device the LMS course menu allowing the student to select either the module/quiz or EOC exam.

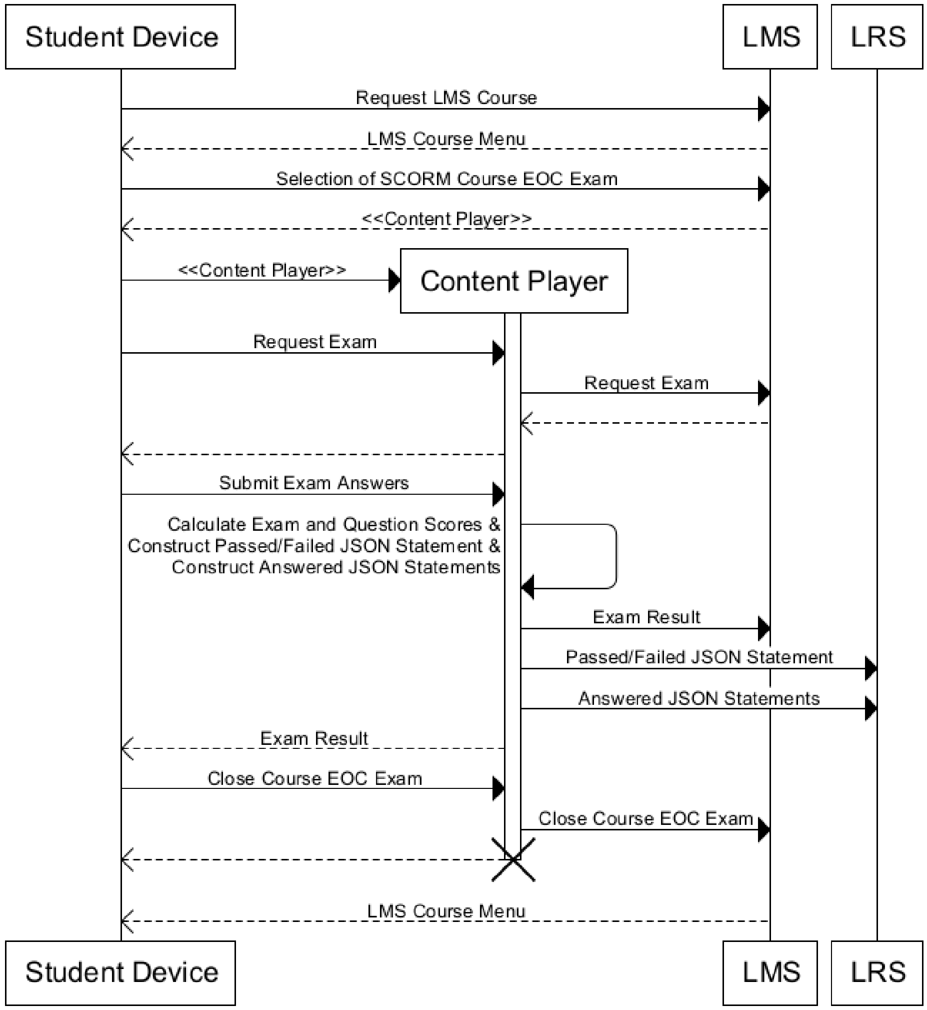
Figure 14. Student Module/Quiz Sequence Diagram. Adapted from Jonathan Poltrack, personal communication, March 14, 2016.



2. EOC Exam Submission

As shown in Figure 15, the student device requests (HTTP get) the LMS course from the LMS which replies (HTTP post) with the menu allowing the student to select the EOC Exam (HTTP get). The LMS responds to the selection the EOC Exam by sending the content player for initialization on the student device (see Figure 9 in Chapter II, Section C for detailed explanation of the content player). Once the content player is initialized on student device, the request for exam questions (HTML/JavaScript) occurs through the content player. The EOC Exam displays all exam questions on the same page and has a single submission for all answers simultaneously. When the student device submits the exam question answers to the content player, the content player calculates the result of each question score individually and constructs answered xAPI statements in JSON format with the properties found in Table 8. The content player uses the results of the exam question scores to calculate a total exam score and construct a passed or failed xAPI statement in JSON format with the properties found in Table 9. The content player then sends the LMS the exam result and the LRS the constructed answered and passed/failed xAPI statements. When the student completes with the EOC Exam the closure request is sent through the content player to the LMS at which time the content player is deconstructed and deleted from the student device. The final step in the process consists of the LMS sending to the student device the LMS course menu allowing the student to select either the module/quiz or EOC exam.

Figure 15. Student EOC Exam Sequence Diagram. Adapted from Jonathan Poltrack, personal communication, March 14, 2016.



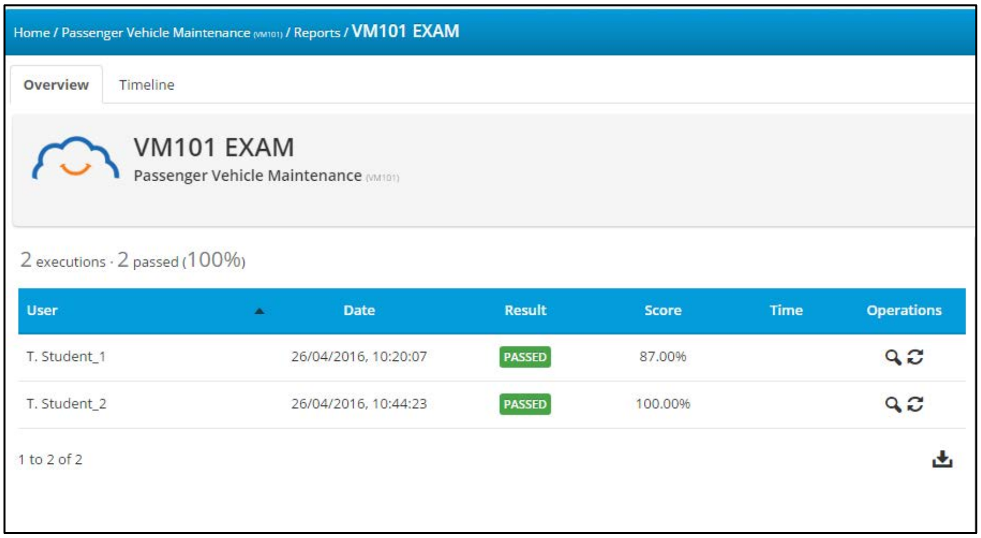
E. LEARNING OBJECTIVE PERFORMANCE VALUE

The purpose of the prototype system is to demonstrate the capture and storage of student learning experiences in JSON format. The learning experiences are then used to calculate learning objective performance values which can then assist educators in the improvement of the education they deliver. A learning objective performance value is a percentage of questions pertaining to a single or group of learning objectives answered correctly by one or more students. To calculate a learning objective performance value, the total number of questions answered correctly is divided by the total number of questions answered and this decimal value is then converted to a percentage. Learning objective performance values calculated in this thesis are: single student/single learning objective, single student/multiple learning objectives (parent subject of multiple learning objectives), multiple students/single learning objective, and multiple students/multiple learning objectives.

1. Administer of Prototype Courseware

The demonstration of the prototype system used two simulated students (Student_1 and Student_2) to complete all portions of the module/quiz and EOC exam for both VM101 and VM201. The student responses to the module/quiz and EOC exam questions were scripted in order to register course completion within the LMS and generate xAPI statements that provide specific calculated learning objective performance values. Each student's completion of VM101 and VM201 updated the LMS course completion data with exam scores and registered the student as passing the course (see Figure 16). The question responses of both simulated students created and stored 64 answered statements and 4 passed statements to the prototype system's LRS. The passed statements generated duplicate the LRS course completion status recorded within the LMS course. A complete list of Student_1 and Student_2 responses to each question in the courseware and the EOC exam scores can be found in Appendix B.

Figure 16. LMS Course Completion with Score.



Instructors view of VM101 LMS completion report depicting Student_1 and Student_2. passing the course and providing the results of the EOC exams. Screenshot from https://cmacthesis.talentlms.com/reports/scormtestinfo/id:1792.

2. Calculation of the Learning Objective Performance Values

There are four property elements needed from the answered statements in order to calculate learning objective performance values: actor.name (Student_#), object.id (Question ID), result.score (Correct or Incorrect), and context.contextActivities.parent.id (Learning Objective ID). To obtain these property elements, the 64 xAPI answered statements in JSON format were retrieved from the LRS, converted to a CSV file, and saved as a Microsoft Excel spreadsheet. The learning objective performance values in Figures 17 and 18 were calculated using the values the four property elements above contained within the Microsoft Excel spreadsheet.

a. Single Student / Single and Multiple Learning Objectives

The single student / single learning objective performance values provide a student's performance by individual learning objective rather than focusing on their exam performance at the end of a course. How well a student scores on exams or quizzes is typically how the learning success of a student is equated too. Figure 17 shows each student passing VM101 and VM201 EOC exams with scores of 75% or greater. Also depicted is each student's individual learning objective performance values and the number of questions answered correctly to the total number of questions. Analyzing the individual learning objective performance values shows that even though both Student_1 and Student_2 passed both courses, they each performed poorly with regard to specific learning objectives (Student_1 with 62.5% in learning objective B and Student_2 with 50% in learning objective E).

The single student / multiple learning objective performance values breakdown a student's performance by the parent subject the individual learning objectives belong to. A collective analysis of learning objectives can show how a well a student performs with regard to particular subjects within a curriculum. Learning objectives A and E are examples of how hydraulic brakes and air brakes would belong to the same parent subject of brakes. Figure 17 depicts Student_2's poor performance in the subject of brakes while scoring high in the other subjects.

Figure 17. Student's Individual Learning Objectives Performance Values.

Learning Objective Performance Values Student_1				Learning Objective Performance Values Student_2			
By Individual Learning Objective	Learning Obj A	75.00%	3/4	By Individual Learning Objective	Learning Obj A	75.00%	3/4
	Learning Obj B	62.50%	5/8		Learning Obj B	100.00%	8/8
	Learning Obj C	100.00%	8/8		Learning Obj C	100.00%	8/8
	Learning Obj D	100.00%	4/4		Learning Obj D	100.00%	4/4
	Learning Obj E	75.00%	3/4		Learning Obj E	50.00%	2/4
	Learning Obj F	75.00%	3/4		Learning Obj F	100.00%	4/4
By Subject	Brakes (L Obj A & E)	75.00%	6/8	By Subject	Brakes (L Obj A & E)	62.50%	5/8
	Electrical (L Obj B)	62.50%	5/8		Electrical (L Obj B)	100.00%	8/8
	Steering (L Obj C)	100.00%	8/8		Steering (L Obj C)	100.00%	8/8
	Engines (L Obj D & F)	87.50%	7/8		Engines (L Obj D & F)	100.00%	8/8
Total	Vehicle Maintenance	81.25%	26/32	Total	Vehicle Maintenance	90.63%	29/32
Total	VM101 EOC Exam	87.00%		Total	VM101 EOC Exam	100.00%	
Total	VM201 EOC Exam	75.00%		Total	VM201 EOC Exam	87.50%	

Learning objective performance values—single student/single learning objective, single student/multiple learning objectives (brakes, electrical steering, engines). Right column—number of questions correct / total number of questions.

b. Multiple Students / Single and Multiple Learning Objectives

The multiple students / single and multiple learning objective performance values provide a group of students' collective performance with regard to individual learning objectives and parent subjects. An analysis of both students' EOC exam results would yield a vehicle maintenance curriculum exam average of 86%. This analysis alone would not identify the poor collective performance values of Student_1 and Student_2 in the learning objective E and the parent subject of brakes (see Figure 18).

Figure 18. Combined Student's Individual Learning Objectives Performance Values.

Learning Objective Performance Values Student_1 & Student_2 Combined			
By Individual Learning Objective	Learning Obj A	75.00%	6/8
	Learning Obj B	81.25%	13/16
	Learning Obj C	100.00%	16/16
	Learning Obj D	100.00%	8/8
	Learning Obj E	62.50%	5/8
	Learning Obj F	87.50%	7/8
By Subject	Brakes (L Obj A & E)	68.75%	11/16
	Electrical (L Obj B)	81.25%	13/16
	Steering (L Obj C)	100.00%	16/16
	Engines (L Obj D & F)	93.75%	15/16
Total	Vehicle Maintenance	85.94%	55/64

Learning objective performance values—multiple students/single learning objective, multiple students/multiple learning objectives (brakes, electrical steering, engines). Right column—number of questions correct / total number of questions.

3. Use of Learning Objective Performance Values

Learning objective performance values can be used by students, instructors, and administrators to determine where areas of education and study should be focused. They help capture a more detailed representation of how well a student or group of students is performing, and whether the instruction or curriculum is effective. Analyzing learning objective performance values over time can assist in determining trends in students' learning, effectiveness of new teaching materials or methods, or success of updated curriculums.

Students can use their own learning objective performance values to determine where their strengths and weaknesses may lie and use that information to determine more efficient methods of studying. Students may also use them to select courses within a curriculum they feel provide them the most useful amount education for what they intend on using it for. Over time, a student can use the trends of their learning objective performance values to assess the effectiveness of the adjustments they made in their education.

Instructors can analyze the learning objective performance values of their students to tailor the instruction they are delivering. By tailoring their courses, instructors can maximize the instruction's efficiency by focusing less time on areas where students excel and more time where they struggle. Instructors can use their students' learning objective performance value trends to make assessments as to the continued effectiveness of the materials, content, assessment questions, or teaching methods they are delivering.

Institutional administrators can use collective learning objective performance values to assist in determining curriculum decisions. Analyzing the collective learning objectives within a curriculum can assist administrators in making decisions as to where educational resources (time, space, and money) should be allocated to provide the most effective education to their students.

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V. CONCLUSIONS AND FUTURE RESEARCH

A. CONCLUSIONS

The prototype system demonstrates a method CDET can use to integrate xAPI into their courseware while capturing relevant learning experiences. These learning experiences are capable of providing valuable data leading to improvement in the effectiveness and efficiency of their education. The LMS Centric architecture provides CDET the benefit of maintaining their existing infrastructure, with the addition of an LRS, while allowing them to focus on updating courseware with xAPI. This architecture also affords CDET the benefit of not disrupting the MarineNet's current course delivery and tracking and allows an opportunity for other educational systems to provide data to the LRS for additional analysis. The limitation with MarineNet established in a LMS Centric architecture is its continued reliance on SCORM compliant courses to deliver e-learning programs. Marines' access to smart devices worldwide, with or without connectivity to a network, provide an opportunity to take advantage of xAPIs ability to capture learning experiences outside the traditional student device-to-LMS connection.

Learning objective performance values provide a quantitative metric that can enable CDET to begin assessing the amount of proficiency a student obtains in individual learning objectives, subjects, or curriculums. The use of learning objective performance values will allow CDET to begin placing specific values on the proficiencies of the learning objectives currently maintained throughout all their courseware providing a more detailed measurement of the intended results of each course. Students' strengths and weaknesses in specific areas can also be determined and used to create tailored curriculums that will allow time and resources to be spent in subject areas that will most benefit the student and the Marine Corps. CDET can also use learning objective performance values to help determine the relevancy and effectiveness of specific course content, learning objectives, and course assessments. The limitations with the learning objective performance values discussed in this thesis are that they were calculated using only assessment questions from self-paced, non-instructor evaluated e-learning courses. More learning experiences from different types of assessments (evaluated practical applications, essay questions, fill-ins, and matching) need to be calculated into the learning objective performance values to make them a more accurate representation of a student's proficiency in a subject area. The analysis CDET can conduct using learning objective performance values and the changes they can enact from that analysis can lead them to improving the effectiveness and efficiency of their e-learning program.

B. FUTURE RESEARCH

The prototype system demonstrated in this thesis was limited in scope to the capture and storage of learning experiences from basic SCORM compliant courses and the calculation of learning objective performance values. Future research in the following topics is recommended to enhance the value of the methods and ideas proposed in this thesis.

1. Curriculum Learning Objective Analysis

This thesis created two courses with limited learning objectives, content, and assessments to demonstrate how xAPI could assist in the calculation of learning objective performance values. The next step would apply the concept of the overlapping learning objectives and parent subjects to an entire curriculum of courses. Applying this concept would allow educators to create a taxonomy of learning objectives providing the relationships necessary to produce the most valuable learning objective performance values to their organization.

- How would a learning objective with a subject of "hydraulic brakes" be a related to the parent subjects of brakes, hydraulics, passenger vehicles, commercial vehicles, and construction vehicles?
- How do learning objectives over multiple curriculums throughout an entire career relate to each other? How can learning objective performance value trends throughout a career be calculated and used in the analysis?

2. LRS Interaction

The interaction with the LRS in this thesis was limited to pulling raw JSON statements off the LRS and converting them to a CSV file. LRSs provide varying levels of analytic tools that can assist a user with providing some level of data analysis.

- What other platforms can the LRS experience statements be exported to? Do those platforms have more capable analytic tools?
- What are the best ways for non-technical individuals (students and instructors) to interact with the data? What data is best presented (the entire experience statement or elements of the statement)? What formats (web application, documents, forms) should be used to present the data?

3. Capture of Learning Experiences

The two learning experiences captured in this thesis were the scores of the question answers and the passed/failed course status with score as they both relate to a learning objective. These learning experiences provide valuable data but are only two of many others occurring while a student interacts with an e-learning course.

- What student-course interactions are occurring and which should be captured and analyzed?
- Beside SCORM courses, what other methods of instruction are occurring within an organization which xAPI could be used to capture learning experiences?
- What other forms of assessments (evaluated practical applications, essay questions, fill-ins) should be captured and how should they be weighed against the others?

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APPENDIX A. PROTOTYPE COURSES

A. VM101—PASSENGER VEHICLE MAINTENANCE COURSE

Hydraulic Brake System Module

Learning Objective A – Without the aid of reference, recall the major components of a vehicle's hydraulic brake system and their purpose.

Content - The major components of a vehicle's hydraulic brake system are the brake pedal, pushrod, master cylinder assembly, hydraulic brake lines, and the brake caliper assembly. The purpose of the hydraulic brake lines is to carry brake fluid from the master cylinder to the brake caliper assembly. The purpose of the brake pedal is to transfer the driver's input requesting to slow the speed of a vehicle to a mechanical action by the entire hydraulic brake system.

Module Quiz Questions (Learning Objective A)

Which of the following is NOT a major component of a vehicle's hydraulic brake system?

a) brake pedal
b) pushrod
c) hydraulic brake lines
d) <u>steering wheel</u>

Which of the following describes the purpose of the hydraulic lines?

a) carry the windshield wiper fluid
b) <u>carry the brake fluid from the master cylinder to the brake caliper assembly</u>
c) carry the electrical current from the ignition to the starter
d) open the vehicle doors

Electrical System Module

Learning Objective B - Without the aid of reference, recall the major components of a vehicle electrical system and their purpose.

Content - The major components of a vehicle electrical system are the engine control unit, alternator, battery, starter solenoid, starter, fuse box, ignition switch, and the starter relay. The purpose of the alternator is to recharge the battery of the power it uses while the vehicle is running. The purpose of the ignition switch is to activate the electrical power of a vehicle. The purpose of the battery is to provide the electrical current needed to start the vehicle. The purpose the starter solenoid is to convert electrical current to mechanical motion to enable the starter motor to start the vehicle.

Module Quiz Questions (Learning Objective B)

Which of the following is NOT a major component of a vehicle's electrical system?

a) fuse box
b) battery
c) <u>tire</u>
d) alternator

Which of the following describes the purpose of the alternator?

a) <u>recharge the battery</u>
b) inflate the tires
c) open the doors
d) cool the engine down

Steering System Module

Learning Objective C - Without the aid of reference, recall the major components of a vehicle's steering system and their purpose.

Content - The major components of a vehicle steering system are the steering wheel, steering column, power steering pump, powering steering fluid reservoir, tie rods, rack and pinon unit, and tires. The purpose of the steering column is to connect the steering wheel to the rack and pinon unit to transfer the driver inputs to the remaining steering assembly. The purpose of the tie rods is to connect the steering assembly to the wheels and ensure the wheels maintain alignment. The purpose of the power steering pump is to provide the hydraulic fluid pressure needed to operate the power steering system. The purpose the power steering fluid reservoir is to store hydraulic fluid needed to operate the power steering system.

Module Quiz Learning Objective C

Which of the following is NOT a major component of a vehicle's steering system?

a) <u>passenger door</u>
b) power steering pump
c) steering wheel
d) steering column

Which of the following describes the purpose of the steering column?

a) <u>transfer driver inputs to remaining steering assembly</u>
b) inflate the tires
c) carry the electrical current from the ignition to the starter
d) cool the engine down

Gasoline Engine Module

Learning Objective D - Without the aid of reference, recall the major components of a gasoline engine and their purpose.

Content - The major components of a gasoline engine are the crankshaft, camshaft, timing belt, fuel injector, intake manifold, exhaust manifold, cylinder head cover, pistons, engine block, spark plugs, electric coil, distributor, and oil pan. The purpose of the crankshaft is to convert the up and down motion of the pistons into rotational motion which enable the turning of the drive train. The purpose of the fuel injector is to provide the proper fuel air mixture to the engine's combustion chambers to enable movement of the pistons.

Module Quiz Learning Objective D

Which of the following is NOT a major component of a gasoline engine?

a) exhaust manifold
b) distributor
c) timing belt
d) <u>steering column</u>

Which of the following describes the purpose of the crankshaft?

a) recharge the battery
b) <u>convert the up and down motion of the pistons into rotational motion</u>
c) increase the speed of the vehicle
d) cool the engine down

Passenger Vehicle Maintenance EOC Exam

Learning Objective A Questions

Which of the following is NOT a major component of a vehicle's hydraulic brake system?

a) master cylinder assembly
b) brake caliper assembly
c) <u>tires</u>

d) brake pedal

Which of the following describes the purpose of the brake pedal?

a) open the windows
b) open the trunk
c) <u>transfer the driver's input to slow the speed of the vehicle into a mechanical action by the entire hydraulic brake system</u>
d) increase the speed of the vehicle

Learning Objective B Questions

Which of the following is NOT a major component of a vehicle's electrical system?

a) alternator
b) <u>trunk</u>
c) fuse box
d) starter solenoid

Which of the following describes the purpose of the ignition switch?

a) <u>activate the electrical power of a vehicle</u>
b) adjust the vehicle seats
c) assist in latching the seat belt
d) store additional fuses

Learning Objective C Questions

Which of the following is NOT a major component of a vehicle's steering system?

a) steering wheel
b) <u>alternator</u>
c) power steering pump
d) rack and pinon unit

Which of the following describes a purpose of the tie rods?

a) activate the electrical power of a vehicle
b) recharge the battery
c) <u>ensure the wheels maintain alignment</u>
d) open the windows

Learning Objective D Questions

Which of the following is NOT a major component of a gasoline engine?

a) camshaft

b) timing belt
c) <u>power steering pump</u>
d) intake manifold

Which of the following describes the purpose of the fuel injector?

a) <u>provide the proper fuel air mixture to the engine's combustion chambers</u>
b) ensure the wheels maintain alignment
c) activate the electrical power of a vehicle
d) transfer the driver's input to slow the speed of the vehicle into a mechanical action by the entire hydraulic brake system

B. VM201—COMMERCIAL VEHICLE MAINTENANCE COURSE

Air Brake System Module

Learning Objective E – Without the aid of reference, recall the major components of a vehicle's air brake system and their purpose.

Content - The major components of a vehicle's air brake system are the compressor, main reservoir, auxiliary reservoir, air dryer, brake pedal, brake pipe, drain valves, and hand brake. The purpose of the compressor is to pump air into the reservoirs to be used in the operation of the air brake system. The purpose of the main reservoir is to store pressurized air to be used in the operation of the air brake system.

Module Quiz Questions (Learning Objective E)

Which of the following is NOT a major component of vehicle's air brake system?

a) brake pedal
b) main reservoir
c) <u>hydraulic brake lines</u>
d) air dryer

Which of the following describes the purpose of the compressor?

a) <u>pump air into the reservoirs</u>
b) open the vehicle doors
c) carry the electrical current from the ignition to the starter
d) carry the brake fluid from the master cylinder to the brake caliper assembly

Electrical System Module

Learning Objective B - Without the aid of reference, recall the major components of a vehicle electrical system and their purpose.

Content - The major components of a vehicle electrical system are the engine control unit, alternator, battery, starter solenoid, starter, fuse box, ignition switch, and the starter relay. The purpose of the alternator is to recharge the battery of the power it uses while the vehicle is running. The purpose of the ignition switch is to activate the electrical power of a vehicle. The purpose of the battery is to provide the electrical current needed to start the vehicle. The purpose the starter solenoid is to convert electrical current to mechanical motion to enable the starter motor to start the vehicle.

Module Quiz Questions (Learning Objective B)

Which of the following is NOT a major component of a commercial vehicle's electrical system?

a) starter
b) starter relay
c) solenoid
d) <u>main reservoir</u>

Which of the following describes the purpose of the battery?

a) inflate the tires
b) adjust the vehicle seats
c) carry hydraulic fluid from the hydraulic reservoir to the brake caliper
d) <u>provide the electrical current needed to start the vehicle</u>

Steering System Module

Learning Objective C - Without the aid of reference, recall the major components of a vehicle's steering system and their purpose.

Content - The major components of a vehicle steering system are the steering wheel, steering column, power steering pump, powering steering fluid reservoir, tie rods, rack and pinon unit, and tires. The purpose of the steering column is to connect the steering wheel to the rack and pinon unit to transfer the driver inputs to the remaining steering assembly. The purpose of the tie rods is to connect the steering assembly to the wheels and ensure the wheels maintain alignment. The purpose of the power steering pump is to provide the hydraulic fluid pressure needed to operate the power steering system. The purpose the power steering fluid reservoir is to store hydraulic fluid needed to operate the power steering system.

Module Quiz Learning Objective C

Which of the following is NOT a major component of a commercial vehicle’s steering system?

a) tie rods
b) drain valves
c) rack and pinon unit
d) steer fluid reservoir

Which of the following describes the purpose of the power steering pump?

a) provide the hydraulic fluid pressure needed to operate the power steering system
b) transfer driver inputs to remaining steering assembly
c) cool the engine down
d) carry the electrical current from the ignition to the starter

Diesel Engine Module

Learning Objective F - Without the aid of reference, recall the major components of a diesel engine and their purpose.

Content - The major components of a diesel engine are the crankshaft, camshaft, timing belt, fuel injector, intake manifold, exhaust manifold, cylinder head cover, pistons, engine block, and oil pan. The purpose of the piston is to transfer the energy caused by the explosion of the fuel/air mixture within the combustion chamber to the crankshaft. The purpose of the camshaft is to convert its rotational motion to a up and down motion through the push rods and rocker arms to open valves into the combustion chambers.

Module Quiz Learning Objective F

Which of the following is NOT a major component of a diesel engine?

a) engine block
b) distributor
c) spark plug
d) fuel injector

Which of the following describes the purpose of the piston?

a) transfer the energy caused by the explosion of the fuel/air mixture within the combustion chamber to the crankshaft
b) increase the speed of the vehicle
c) convert the up and down motion of the pistons into rotational motion
d) cool the engine down

Commercial Vehicle Maintenance EOC Exam

Learning Objective E Questions

Which of the following is NOT a major component of a vehicle's air brake system?

a) <u>master cylinder assembly</u>
b) hand brake
c) drain valves
d) auxiliary reservoir

Which of the following describes the purpose of the main reservoir?

a) transfer the driver's input to slow the speed of the vehicle into a mechanical action by the entire hydraulic brake system
b) adjust the vehicle's seats
c) open the trunk
d) <u>store pressurized air</u>

Learning Objective B Questions

Which of the following is NOT a major component of a vehicle's electrical system?

a) <u>auxiliary reservoir</u>
b) alternator
c) fuse box
d) starter solenoid

Which of the following describes the purpose of the starter solenoid?

a) store additional fuses
b) <u>convert electrical current to mechanical motion to enable the starter motor to start the vehicle</u>
c) assist in latching the seat belt
d) store pressurized air

Learning Objective C Questions

Which of the following is NOT a major component of a vehicle's steering system?

a) steering column
b) <u>fuel injector</u>
c) tires
d) rack and pinon unit

Which of the following describes a purpose of the power steering fluid reservoir?

a) ensure the wheels maintain alignment
b) activate the electrical power of a vehicle

c) recharge the battery

d) store hydraulic fluid needed to operate the power steering system

Learning Objective F Questions

Which of the following is NOT a major component of a diesel engine?

a) exhaust manifold

b) compressor

c) timing belt

d) oil pan

Which of the following describes the purpose of the camshaft?

a) open the trunk

b) convert its rotational motion to a up and down motion through the push rods and rocker arms to open valves into the combustion chambers

c) activate the electrical power of a vehicle

d) transfer the driver’s input to slow the speed of the vehicle into a mechanical action by the entire hydraulic brake system

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APPENDIX B. COURSEWARE QUESTION RESPONSES

Student Response—1 indicates a correct response, 0 indicates an incorrect response.

VM101 Module/Quiz					
Type of Statement	**Learning Obj**	**Learning Obj Subject**	**Question**	**Student_1 Response**	**Student_2 Response**
Answered	LO_A	Hydraulic Brakes	VM101_HYD_1	1	0
Answered	LO_A	Hydraulic Brakes	VM101_HYD_2	1	1
Answered	LO_B	Electrical	VM101_ELE_1	0	1
Answered	LO_B	Electrical	VM101_ELE_2	0	1
Answered	LO_C	Steering	VM101_STE_1	1	1
Answered	LO_C	Steering	VM101_STE_2	1	1
Answered	LO_D	Gasoline Engines	VM101_GAS_1	1	1
Answered	LO_D	Gasoline Engines	VM101_GAS_2	1	1

VM101 EOC Exam					
Type of Statement	**Learning Obj**	**Learning Obj Subject**	**Question**	**Student_1 Response**	**Student_2 Response**
Answered	LO_A	Hydraulic Brakes	VM101_EXAM_1	0	1
Answered	LO_A	Hydraulic Brakes	VM101_EXAM_2	1	1
Answered	LO_B	Electrical	VM101_EXAM_3	1	1
Answered	LO_B	Electrical	VM101_EXAM_4	1	1
Answered	LO_C	Steering	VM101_EXAM_5	1	1
Answered	LO_C	Steering	VM101_EXAM_6	1	1
Answered	LO_D	Gasoline Engines	VM101_EXAM_7	1	1
Answered	LO_D	Gasoline Engines	VM101_EXAM_8	1	1

VM201 Module/Quiz					
Type of Statement	**Learning Obj**	**Learning Obj Subject**	**Question**	**Student_1 Response**	**Student_2 Response**
Answered	LO_E	Air Brakes	VM201_AIR_1	1	0
Answered	LO_E	Air Brakes	VM201_AIR_2	1	1
Answered	LO_B	Electrical	VM201_ELE_1	1	1
Answered	LO_B	Electrical	VM201_ELE_2	1	1
Answered	LO_C	Steering	VM201_STE_1	1	1
Answered	LO_C	Steering	VM201_STE_2	1	1
Answered	LO_F	Diesel Engines	VM201_DIE_1	0	1
Answered	LO_F	Diesel Engines	VM201_DIE_2	1	1

VM201 EOC Exam					
Type of Statement	**Learning Obj**	**Learning Obj Subject**	**Question**	**Student_1 Response**	**Student_2 Response**
Answered	LO_E	Air Brakes	VM201_EXAM_1	0	0
Answered	LO_E	Air Brakes	VM201_EXAM_2	1	1
Answered	LO_B	Electrical	VM201_EXAM_3	0	1
Answered	LO_B	Electrical	VM201_EXAM_4	1	1
Answered	LO_C	Steering	VM201_EXAM_5	1	1
Answered	LO_C	Steering	VM201_EXAM_6	1	1
Answered	LO_F	Diesel Engines	VM201_EXAM_7	1	1
Answered	LO_F	Diesel Engines	VM201_EXAM_8	1	1

EOC Exam Scores			
		Student_1 Exam Score	**Student_2 Exam Score**
Passed	VM101	87.00%	100.00%
Passed	VM201	75.00%	87.00%

LIST OF REFERENCES

ADL LRS. (n.d.). Advanced Distributed Learning. Retrieved May 2016, 3, from http://adlnet.gov/adl-lrs/

Advanced Distributed Learning Co-Laboratories. (n.d.). Retrieved May 10, 2016, from https://github.com/adlnet/xAPI-Spec/blob/master/xAPI.md#statement

College of Distance Education and Training. (2012, July 12). *MarineNet courseware development technical standards 2.0* [Technical standard]. Retrieved from https://www.mcu.usmc.mil/cdet/docs/courseware/MarineNet_Courseware_Development_Technical_Standards_v2-0.pdf

Creating exams. (n.d.). Retrieved May 3, 2016, from https://www.cmu.edu/teaching/assessment/assesslearning/creatingexams.html

Department of Defense. (2006, June 16). *Development, management, and delivery of distributed learning* (DOD Instruction 1322.26). Retrieved from http://www.dtic.mil/whs/directives/corres/pdf/132226p.pdf

Experience API. (n.d.). Retrieved February 6, 2016, from http://adlnet.gov/adl-research/performance-tracking-analysis/experience-api/

Goal 3. (n.d.). Retrieved May 3, 2016, from https://www.mcu.usmc.mil/SitePages/aboutus/Vision%20Statement.aspx

Grance, T., & Mell, P. (2011, September). *The NIST definition of cloud computing* (Special Publication 800-145). U.S. Department of Commerce. Retrieved from http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf

Internet Engineering Task Force. (2012, October). *RFC 6749: The OAuth 2.0 Authorization Framework* [Proposed standard]. Retrieved March 5, 2016, from https://tools.ietf.org/html/rfc6749

Introducing JSON. (n.d.). Retrieved May 3, 2016, from http://www.json.org/

Jäätmaa, J. (2009). Financial aspects of cloud computing business models (Master's thesis). Retrieved from http://epub.lib.aalto.fi/en/ethesis/pdf/12435/hse_ethesis_12435.pdf

Kuhlmann, T. (2009, May 19). Are your e-learning courses pushed or pulled? [Blog post]. Retrieved from http://blogs.articulate.com/rapid-elearning/are-your-e-learning-courses-pushed-or-pulled/

MCU mission statement. (n.d.). Retrieved May 3, 2016, from https://www.mcu.usmc.mil/SitePages/aboutus/Vision%20Statement.aspx

LMS Centric. (n.d.). Retrieved May 3, 2016, from http://adlnet.github.io/SCORM-to-TLA-Roadmap/phase1/lms-centric.html

Office of Distance Learning. (2011). *Instruction at FSU: A guide to teaching and learning practices* (7th ed.) [Electronic handbook]. Retrieved from https://distance.fsu.edu/instructors/instruction-fsu-guide-teaching-learning-practices

Patrick, S., Edwards, D., Wicks, M., & Watson, J. (2012). *Measuring quality from inputs to outcomes: Creating student learning performance metrics and auality assurance for online schools* [Report]. International Association for K-12 Online Learning. Retrieved from http://www.inacol.org/wp-content/uploads/2015/02/iNACOL_Quality_Metrics.pdf

Poltrack, J., & Creighton, T. (2015). Opening legacy data silos: Using experience data for educational impact. Paper presented at the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2015, Orlando, FL. Retrieved from https://www.academia.edu/18930732/Opening_Legacy_Data_Silos_Using_Experience_Data_for_Educational_Impact

Rustici, M. (2009, January 13). Content packaging. Retrieved from http://scorm.com/scorm-explained/technical-scorm/content-packaging/

SCORM to TLA roadmap. (n.d.). Retrieved May 3, 2016, from http://adlnet.github.io/SCORM-to-TLA-Roadmap/index.html

Sener, J. (2015, July 15). Updated e-learning definitions [Blog post]. Retrieved from http://onlinelearningconsortium.org/updated-e-learning-definitions-2/

Ways to present content in an online course…. (n.d.). Retrieved May 3, 2016, from http://www.uwlax.edu/catl/instructionaldesign/content_online.pdf

Welcome to CDET!. (n.d.). Retrieved May 3, 2016, from https://www.mcu.usmc.mil/cdet/SitePages/home.aspx

Why should assessments, learning objectives, and instructional strategies be aligned? (n.d.). Retrieved May 3, 2016, from https://www.cmu.edu/teaching/assessment/basics/alignment.html

xAPI architecture overview. (n.d.). Retrieved May 3, 2016, from http://adlnet.gov/adl-research/performance-tracking-analysis/experience-api/xapi-architecture-overview/

xAPI background & history. (n.d.). Retrieved May 3, 2016, from http://adlnet.gov/adl-research/performance-tracking-analysis/experience-api/xapi-background-history/

xAPI statement data model [Online image]. (n.d.). Retrieved May 3, 2016, from https://drive.google.com/file/d/0BxhK5TH2EsphZFBXeVNnSGozWEE/view

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