Bridging the SCORM and xAPI Gap: The Role of cmi5

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ABSTRACT

The variety and complexity of applications in the learning and training industry are advancing rapidly. Sharable Content Object Reference Model (SCORM®) standards, however, have not been extensible enough to support emerging technologies and do not provide enough guidance to adequately capture learning and performance data. The Department of Defense (DoD) Instruction 1322.26 states that the Experience Application Programming Interface (xAPI) data specification is the superior strategy for tracking learning data, but xAPI cannot simply replace SCORM. In 2016, cmi5 (the specification's name; no longer stands for Computer Managed Instruction) was modified to bridge the SCORM and xAPI gap. The specification defines a set of rules for how online courses are imported, launched, and tracked using a Learning Management System (LMS) and xAPI. cmi5 will play a vital role in the DoD's modernization effort, facilitating progress from SCORM-based LMS-centric courseware to a distributed learning "ecosystem," delivering diverse learning opportunities across federated platforms. However, there was not a conformance test suite and governance of cmi5, which, until now, has slowed adoption rates of cmi5 and xAPI within the DoD. We developed cmi5 conformance test suites, an open-source player prototype, and governance for the cmi5 specification, which were recently released by the Advanced Distributed Learning (ADL) Initiative. This paper provides an overview of SCORM, xAPI, and cmi5 standards, demonstrates how cmi5 can help transition to a modern, distributed learning ecosystem, and shares information about the new tools now available.

ABOUT THE AUTHORS

Brian Miller is known as one of the world's foremost xAPI thought leaders and a chief contributor to the cmi5 working group. He was the architect and principal engineer for ADL's Project CATAPULT, a freely available, open-source cmi5 content player and conformance test suites for use by Department of Defense stakeholders and eLearning technology vendors as a way to test and validate content for cmi5 conformance. He has more than 20 years of professional and eLearning industry experience. In 2012, Brian joined Rustici Software and has worked on Project CATAPULT, Project Tin Can, standards support, open-source libraries, and leading the Rustici Engine team.

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Andy Johnson has worked professionally in distributed learning technology for the last 17 years, proudly serving the Department of Defense as a SETA contractor for 15 of those years. He was a developer of SCORM and has been involved in every version. He has been the xAPI lead at the ADL Initiative since version .9. He currently serves as the Specifications and Standards Manager and manages a project team's efforts in advancing technical specifications and standards in the training and education domain. Andy received his bachelor's degree in Computer Science and master's degree in Education, Communication, and Technology from the University of Wisconsin-Madison. He leads open-source development efforts of standards as a member of the Institute of Electrical and Electronics Engineers (IEEE).

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INTRODUCTION

Two decades ago, learners transitioned from computer-based training, such as content stored on CDs, to online, web-based learning, but it became apparent that playing content and system interoperability were challenges. A common, standardized reference model was needed to address the problems associated with eLearning content, including interoperability, portability, reusability, and instructional sequencing (Advanced Distributed Learning Initiative [ADL], n.d.). To meet those needs and overcome interoperability challenges, the Advanced Distributed Learning (ADL) Initiative developed the Sharable Content Object Reference Model (SCORM®) standard.

Today, a similar situation is occurring in the learning and training industry. New technologies and applications are advancing rapidly, and SCORM is not extensible enough to support those technologies nor does it provide adequate governance for capturing data. Modernization efforts by the Department of Defense (DoD), including DoDI 1322.26, declare the Experience Application Programming Interface (xAPI) specification as the superior model for tracking learning activities (Office of the Under Secretary of Defense for Personnel and Readiness, 2017), but it is a large leap to migrate wholesale from a legacy SCORM-based learning model to xAPI.

To bridge this divide, the cmi5 specification was modified to provide a set of rules for how online courses are imported, launched, and tracked using a Learning Management System (LMS) and xAPI, which is an essential part of the DoD's modernization initiatives. Even with the DoD focusing on learning and training innovation, adoption of the cmi5 and xAPI standards has been slow because key support components were absent. Now, new cmi5 tools, governance of the specification, and guidance for migrating legacy content are available to help increase adoption by government agencies and vendors.

SCORM

The technical learning standard, the Sharable Content Object Reference Model (SCORM), defines a set of rules for developers on how to properly apply the standards in order for courseware to be interoperable between systems (SCORM.com, n.d.). The Reference Model part of SCORM refers to the fact that it was built on top of existing standards. SCORM, the current de facto interoperability standard, is purely technical, which means it governs how systems "talk to" each other and does not refer to the information in the courses, content, or materials. SCORM was intentionally designed to meet the DoD's requirements for creating interoperable, browser-based learning content (ADL, n.d.).

SCORM describes how to create "Sharable Content Objects" or "SCOs" that can be used in different systems and contexts. SCOs are the smallest part of training that are reusable, such as a module, chapter, page, or section (O. Bohl et. al., 2002). Assembled together, multiple SCOs form a learning or training course.

At its core, SCORM is a tool that allows for beneficial, orderly online training and for content creators to distribute their courseware to a variety of Learning Management Systems (LMSs) efficiently. SCORM also helps LMSs handle and play different content pieces from a variety of sources (SCORM.com, n.d.).

Versions of SCORM

Since its inception, there have been several iterations of SCORM and there are three versions that are relevant and supported by ADL today: SCORM 1.2, SCORM 2004 3rd Edition, and SCORM 2004 4th Edition.

Released in 2001, SCORM 1.2 is currently the most widely used version today and is supported by almost every commercial authoring tool and LMS on the market. SCORM 1.2 captures completion, score, duration, satisfaction, and limited interaction data. However, SCORM 1.2 had several holes in providing reusable content, as it did not specify how an LMS will handle multiple SCOs for the purposes of controlling the learner's flow through the course or for measuring learner's satisfaction. Consequently, SCORM 2004 was designed to address those challenges.

Generally, the phrase "SCORM 2004" refers to any of the editions, but each edition differs slightly. SCORM 2004 2nd edition was released to fix defects detected with SCORM 2004 1st Edition, which is not deployable or used, and ADL no longer supports the use of SCORM 2004 2nd Edition. Released in 2006, SCORM 2004 3rd Edition is the most common edition and is mostly a set of improvements with sequencing to remove ambiguities and strengthen the specification for better interoperability. SCORM 2004 4th Edition further removed sequencing uncertainty and introduced new sequencing features, which made creating sequenced content simpler. Vendors and content providers should strive to support all three versions of SCORM 2004 to appeal to the broadest audience (SCORM.com, n.d.). LMSs should allow SCORM 2004 2nd Edition imports but should be careful of issues that could cause problems with interoperability and should be handled as 3rd Edition packages.

Benefits and Limitations

Besides being the most widely used learning and training standard, SCORM offered a variety of benefits for organizations seeking to deliver training to learners. The following benefits, originally titled "ilities," were identified when the SCORM 2004 3rd Edition was introduced in 2006:

1. **Accessibility**: The ability to locate and access instructional components from one remote location and deliver them to many other locations.
2. **Adaptability**: The ability to tailor instruction to individual and organizational needs.
3. **Affordability**: The ability to increase efficiency and productivity by reducing the time and costs involved in delivering instruction.
4. **Durability**: The ability to withstand technology evolution and changes without costly redesign, reconfiguration, or recoding.
5. **Interoperability**: The ability to take instructional components developed in one location with one set of tools or platform and use them in another location with a different set of tools or platform.
6. **Reusability**: The flexibility to incorporate instructional components in multiple applications and contexts. (ADL Initiative, 2006, p.14)

SCORM was introduced two decades ago, and as technologies have evolved, what were once considered the benefits of the standard are now limitations, including adaptability and durability. The standard does not provide enough guidance to adequately capture both learning and performance data. SCORM is limited to tracking browser-based learning content and is not extensible enough to track newer technologies, such as virtual reality, simulations, games, and mobile activities, or offline activities, like reading. In addition, SCORM content must reside in the same domain as the LMS (Werkenthin, 2015). Finally, as web languages and best practices have evolved, the standard hasn't been flexible enough to stay current with these changes (Johnson & Hruska, 2013).

SCORM Uses Cases and Adoption

For the use case of delivering browser-based learning activities requiring minimal tracking from an LMS, SCORM is still very relevant and prevalent in the industry today. Content providers looking to integrate with outside vendors will want their courses to be SCORM conformant in order to provide their content to the largest audience. Organizations or departments that are building a large library of learning content will need their content to be playable in different systems. Organizations that continue to use SCORM content must ensure that the content is conformant to their LMS's accepted SCORM version.

Due to its tenure, SCORM is the most widely supported standard today, but newer, more modern standards have been introduced that are more flexible and extensible.

xAPI

SCORM's gaps and limitations led to the need for standards to be developed to meet the changing requirements of advancing technologies (Johnson & Hruska, 2013) and to track a variety of formal and informal learning experiences that occur in and beyond computer-based training (ADL Initiative & U.S. Department of Defense [DoD], 2013). Released in 2013, the technical specification Experience Application Programming Interface (xAPI) was constructed from these needs. xAPI "specifies a structure to describe learning experiences and defines how these descriptions can be exchanged electronically" (ADL Initiative & U.S. DoD, 2013, sect. 1.0).

xAPI is an open-source data and interface Institute of Electrical and Electronics Engineers (IEEE) draft standard that permits software applications to capture and share data on learning experiences and performance. This allows for more data about learners to be recorded and then analyzed, which could fundamentally alter the way training programs are conducted, managed, and measured. The standard can be implemented into nearly any learning technology, including old and new technologies (ADL Initiative, n.d.).

xAPI strives to make analyzing and comparing learning experience and outcomes easier, even when activities are recorded in disparate contexts, systems, or technologies. The standard also seeks to maximize interoperability between platforms and services that produce, collect, store, and analyze learning data. xAPI provides a blueprint for developers building applications that need to implement or conform to the specification (ADL Initiative & U.S. DoD, 2013).

Two of the key elements represented in the xAPI standard include xAPI statements, or learning records, that represent learning activity data and a Learning Record Store (LRS) for storing and sharing those records. Activity providers, often referred to as Learning Record Providers (LRPs), represent the content or learning activity that is capturing learner activity in the form of xAPI statements. It is important to note that xAPI does go beyond the xAPI Statement.

xAPI Statements

xAPI statements can serve the role of evidence for any sort of experience or event tracked in xAPI. While statements follow a machine readable JSON (JavaScript Object Notation) format, they can also easily be described using natural language, which is extremely useful for the design process. Statements are meant to be aggregated and analyzed to provide larger meaning for the overall experience rather than just the sum of its parts (ADL Initiative & U.S. DoD, 2013). Statements must include an actor, verb, and object, which records the learner, the action, and the activity. xAPI statements may be expanded to include additional components to capture even more granular details, such as context (e.g., activity instructor, learner location) or result (e.g., score). Below are two examples of xAPI statements to illustrate the range of data that may be collected:

> Required: Sally (actor) passed (verb) Solo Hang Gliding (object/activity)
> Expanded: Sally passed Solo Hang Gliding with Instructor Jones (context) with a score of 90% (result).

Learning Record Store (LRS)

The LRS is defined within the specification as a "server (i.e., system capable of receiving and processing web requests) that is responsible for receiving, storing, and providing access to Learning Records" (ADL Initiative & U.S. DoD, 2013, Sect. 4.0). LRSs may be stand-alone services or embedded within an LMS or other system to collect xAPI statements from any authorized LRP. The LRS plays a critical role in the digital learning ecosystem as "LRSs are responsible for storing, accessing, and often visualizing the data about learning experiences, activities, and performance. LRSs also validate the format of the statements, ensuring that only conformant statements are accepted and retained" (ADL Initiative, n.d.).

xAPI Profiles

The data that xAPI statements can capture is virtually limitless, so a defined vocabulary becomes necessary in order for the data to be interpreted in the same way across systems and platforms. The xAPI Profile Specification establishes rules for individual xAPI Profiles to leverage concepts, extensions, statement templates, and statement patterns in order to present clearer, more consistent data that is readable by both humans and systems. This data can then be used to help organizations better understand the behaviors of their learners and users (ADL Initiative, n.d.).

Essentially, xAPI Profiles are roadmaps that drive successful implementation and semantic interoperability of xAPI data across systems. Data points alone are simply that: points of data. To make sense of that data, you need a guide to connect the points and interpret what they mean in order to draw accurate conclusions.

Benefits and Limitations

The most beneficial aspects of xAPI are enhanced data interoperability and the capacity to capture a wide variety of learner experiences. xAPI was designed to be simple and flexible with many of the existing restrictions, including dependencies on LMSs and browser-based content, being lifted (xAPI.com, n.d.). xAPI enables the capture of a virtually infinite amount of data within a learning activity and provides a mechanism for tracking a wider variety of activities beyond the browser-based content to which SCORM is tethered. This data can then be analyzed to see how training activities impact employee performance goals (xAPI.com, n.d.).

In addition to data tracking and interoperability, organizations implementing xAPI can see several benefits that SCORM is unable to provide. xAPI can be used to report on learning experiences outside of an LMS, and learning content does not have to reside in the LMS or web browser. Courses are not restricted to "launching" from an LMS, which opens up the ability to use mobile applications, simulations, and gaming. xAPI also employs modern technology, such as JSON and REST (Representational State Transfer) (RISC Inc., n.d.).

While flexibility is one of xAPI's biggest strengths, its versatile and extensible data model can also make it challenging to extrapolate and analyze the data in a meaningful way. This flexibility can result in challenges when it comes to both systematic and semantic interoperability. Said another way, with the freedom to select virtually any verb to describe an action, there is a risk that multiple verbs may be used to describe the same action. This results in systems being unable to correlate or capture the intent holistically. xAPI Profiles were introduced to overcome this risk by defining vocabulary, contexts, and rules for how xAPI data interacts within a particular domain (ADL Initiative, n.d.). However, a common vocabulary or profile is needed in order for larger audiences to better understand the data in an xAPI Statement (xAPI.com, n.d.).

xAPI Use Cases and Adoption

One of the more appealing aspects of xAPI is that it can be used to record data from newer technologies, which include simulations, virtual reality, games, and mobile. xAPI can also be used to record offline activities, such as blended, team-based, and long-term learning experiences. Other xAPI use cases include when an LMS isn't required, the content needs to be accessed from any device, the content creator wants to keep control of content, or the course requires reporting multiple scores.

xAPI tracking capabilities extend far beyond recording completion, duration, mastery, and score that SCORM is known for. The options for what learning data can be tracked using xAPI are virtually infinite as are potential use cases.

The Department of Defense (DoD) Instruction 1322.26 declares that the xAPI data standard is the superior strategy for tracking learning data. xAPI, however, cannot directly replace SCORM because SCORM includes aspects, like content packaging and session management, that xAPI does not include. xAPI does not address or specify "launched" activities from an LMS, and without instructions for use with an LMS, adoption rates have been slow.

cmi5

Designed to bridge the divide between SCORM and xAPI, the cmi5 specification is an xAPI Profile for using xAPI in the context of a traditional launching system or Learning Management System (LMS). cmi5 defines how learning and training resources are imported, launched, and tracked in a way that is similar to SCORM while providing more advanced opportunities by conforming to the xAPI specification (ADL Initiative, n.d.). cmi5 employs controlled vocabularies, which are required for interoperability between learning content and LMSs, and uses xAPI as the communication and data layer (Aviation Industry Computer-Based Training Committee [AICC], n.d.).

Like xAPI, cmi5 can record activities performed outside of an LMS, but unlike xAPI, those activities must be launched by an LMS. xAPI on its own, however, is highly generalized and requires a defined rule set to ensure plug and play interoperability between learning activities and systems. The cmi5 profile is specifically created for use with an LMS where the learner launches the learning content or activity from an LMS user interface and defines interoperability rules for content launch mechanism, authentication, session management, reporting, and course structure (AICC, n.d.).

cmi5 Components

There are four primary components to cmi5: Assignable Unit (AU), Course Package, LMS, and Learning Record Store (LRS). Within the cmi5 course structure, each learning activity is called an AU and has several properties. One example of an AU property is the "moveOn" value. It is used to determine if the AU has been successfully satisfied and the learner is able to "move on" to other AUs (ADL Initiative, n.d.). The Course Package is the course structure that defines assignable units and their metadata to represent a course. The Course Package can be optionally packaged in a ZIP file with any discretionary learning media files. Learners will use an LMS to launch cmi5 content, and the LMS will register learners, launch the content, track the learner's progress, and analyze and report on learner performance. The LMS also sends xAPI statements to an LRS, and the LRS receives, stores, and retrieves the xAPI statements (Johnson et al., 2021).

cmi5 in Action

From course creation to reporting, this is the overall process for a typical cmi5 case (see Figure 1). The author creates AUs, or content, that use xAPI to capture learner data and assembles AUs into a course structure with instructions for launch, description, and identification. The author also provides satisfaction rules, such as setting a mastery score. The AU's resources may be referenced via an XML file from an external host or saved as a ZIP file along with the course structure. Once complete, the administrator imports the course package into the LMS. The administrator enrolls learner(s) in the course, and the LMS records the enrollment as a registration. The learner initiates the launch of an AU, and the LMS prepares launch data and records the launch in the LRS. The LMS then redirects the learner to the AU presentation, and the learner interacts with the AU. The AU records activities, scores, mastery, and completion to the LRS and then continues on to additional AUs.

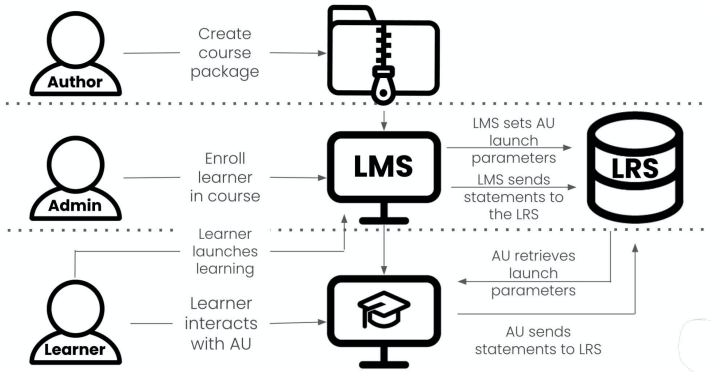

Figure 1. cmi5 Components and Process

Benefits of cmi5

cmi5 opens up the best of both worlds: the flexibility that xAPI introduces for tracking virtually any type of learning activity and the structure of SCORM that learning technologies and systems have historically relied upon. The cmi5 specification's primary focus is on being more extensible, robust, and adaptable to today's technologies than existing standards (AICC, n.d.). Organizations implementing the specification will have the enhanced benefits that xAPI provides while achieving several tracking and interoperability goals.

cmi5 incorporates a simplified tracking data model by only specifying the essential elements needed to be interoperable across most learning instances, such as score, status, and time. While cmi5 only specifically defines the necessities, it enables the implementation of systems capable of recording and reporting or retrieving content-defined data, which permits content authors and designers to add features in the future without sacrificing interoperability. The specification also supports Content as a Service (CaaS) models of delivery so that content can be stored outside of an LMS. Unlike SCORM, cmi5 is not dependent on a browser to communicate or launch courses, content, or experiences (AICC, n.d.). It is important to remember that cmi5 is a floor, not a ceiling. It provides a solid foundation where more features can be added.

The xAPI specification does not define how online courses are structured or how the learning content communicates with the system that is hosting that content. cmi5 solves these by specifically outlining rules and definitions for content launch, authorization, session management, reporting, and course structure (ADL Initiative, n.d.).

cmi5 Use Cases and Adoption

cmi5 solves the LMS use case where the learner needs to launch content from an LMS-based system and therefore needs defined rules. Potential examples of when cmi5 would be the right standard include incorporating training content with simulations, virtual reality, gamification, mobile applications, or video-based training launched from, and tracked in, an LMS. In addition, cmi5 can be implemented with all of the same use cases of xAPI, including tracking learning activities performed with newer technologies and training completed offline.

Adoption rates for cmi5 have been slow thus far because conformance testing and implementation guidance have been missing. Specifically, the DoD has not yet acquired cmi5-based content because of a lack of LMSs and authoring tools that support cmi5 and because there has not been a software conformance test suite for validating whether courseware or platforms adhere to the specification.

COMPARING THE STANDARDS

Learning and development professionals will want to use the right standard for the right learning activity, but between the versions of SCORM, xAPI and cmi5, there are a variety of options. Table 1 lists a few key features that professionals creating or acquiring training content should be aware of and which standards support those features (AICC, n.d., n.d.). This table can help determine which standards are best suited for which needs (see Table 1).

Table 1. Comparison of Key SCORM, xAPI, and cmi5 Features

Features	SCORM	xAPI	cmi5	Description
Defined content launch	Y	N	Y	SCORM and cmi5 define content launch. xAPI does not include instructions for launching content in an LMS.
Track "anything"	N	Y	Y	SCORM is constrained to a defined set of data elements while xAPI and cmi5 allow for developer defined data elements.
Normalized reporting	Y	N	Y	cmi5 establishes rules for records (statements) to include identifiers for a learner session so that records can be more easily grouped for normalized reports.

Mobile apps	N	Y	Y	SCORM cannot track mobile applications natively and only operates within a browser context. With cmi5 or xAPI, mobile access to an LMS can be through a mobile web browser directly using the LMS, mobile app embedding a web browser, or mobile app using native UI components.
Distributed content	N	Y*	Y	All SCORM content must reside on the same server or domain as the LMS. Content can be located anywhere with cmi5. *xAPI does not define a content packaging standard, but xAPI supports the concept of a learning activity residing anywhere.
Data portability	N	Y	Y	SCORM data is collected and stored within the LMS. xAPI and, by extension cmi5, allow for data to be shared across systems.
Extensibility	N	Y	Y	With cmi5 and xAPI, any learning data content can be captured. The LMS uses an LRS to support cmi5 and xAPI. With an LRS, you can build a learning ecosystem beyond the LMS, easily connecting to other systems.
Normalized satisfaction criteria	Y	N	Y	cmi5 establishes interoperable rules for determining completion/mastery of learning activities. xAPI has no defined satisfaction criteria.
Multiple lesson support	Y	N	Y	cmi5 packages allow for multiple AUs in a defined hierarchy with criteria for progression, much as SCORM does with multiple SCOs.

cmi5'S ROLE IN MODERNIZING LEARNING AND TRAINING

Whether it is simulations, virtual reality, or gamification, advanced technologies are impacting training and changing the future of learning. LMSs continue to be a key component of formal and educational training, but the DoD is looking to incorporate, or is incorporating, these new technologies into training programs. The ADL Initiative's Total Learning Architecture (TLA) "defines a set of specifications and standards for connecting these various experiences to one another and throughout an individual's lifelong continuum of learning" (ADL Initiative, n.d.).

cmi5 bridges the gap between legacy SCORM courseware and modern platforms using xAPI. cmi5 allows for more flexibility than SCORM provides while including a defined set of vocabulary and launch instructions that are necessary with LMS use and that are not specifically expressed with the xAPI standard. cmi5 and xAPI are among the many interdependent components needed to enable modernization efforts across the DoD and federated platforms (ADL Initiative, n.d.).

THE ROAD AHEAD FOR cmi5

Knowing the limitations of SCORM and seeing a need for more modern learning standards, DoDI 1322.26 was renewed in 2017 and included the recommendation for xAPI. This Instruction outlines the goal of transitioning from legacy SCORM-based, LMS-centric courseware to a more modern learning ecosystem (which is defined in both the DoDI 1322.26 and the ADL's TLA initiative) with the capability to provide diverse learning opportunities across federated platforms. However, there is a large divide between migrating legacy tools and xAPI.

In 2020, the ADL Initiative awarded a contract to Rustici Software to build freely available, open-source tools to provide a way to test and validate content and systems. Formerly known as Project CATAPULT (cmi5 Advanced Testing Application and Player Underpinning Learning Technologies), the project also included a set of best practices and exemplar courses with templates and instructions to assist with migrating legacy courseware to conform to the cmi5 specification. These tools were developed to help facilitate the enterprise adoption of xAPI and cmi5 across the Department of Defense and will remove the barrier to entry and obstacles that many organizations face when trying to create, procure, and implement cmi5 conformant content or systems.

cmi5 Conformance Test Suites

In order to comply with DoDI 1322.26, DoD entities must only use components that are compliant with current eLearning standards. The DoD requires a way to verify that cmi5 software applications, systems that support the specification, and cmi5 content are fully conformant to the cmi5 specification. The cmi5 conformance test suites validate that all aspects of cmi5 content and systems supporting cmi5 conform to the specification requirements.

Two cmi5 conformance test suites were developed: a cmi5 Content Test Suite (CTS) for cmi5 content (see Figure 2) and a cmi5 LMS Test Suite (LTS) for cmi5 conformant systems (see Figure 3). The CTSs permit testing and validation for conformant courses and applications and have broad applicability for the DoD, governmental agencies, contractors, and industry. All acquired content that is cmi5-based and systems that support the specification should be tested in a conformance test suite and have passed prior to acceptance by government agencies. Both conformance test suites are hosted by ADL and available for individual download.

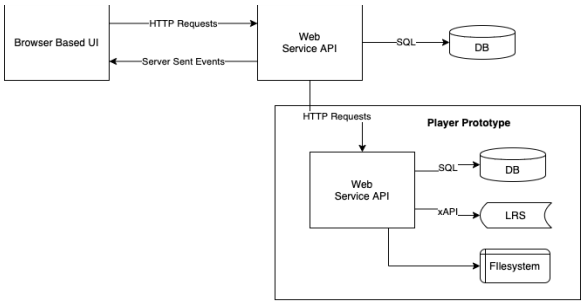

Figure 2. Content Testing

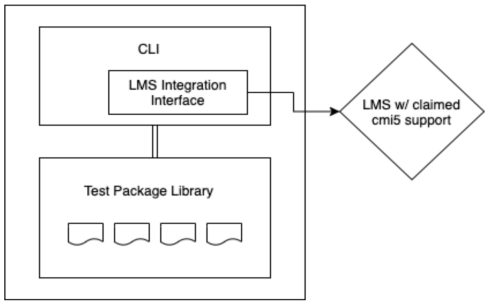

Figure 3. LMS and Systems Testing

Open-Source cmi5 Content Player Prototype

The open-source, web-based cmi5 player prototype supports software development and content migration efforts and provides a fundamental capability for delivering cmi5 courses across the DoD. No other bundled software applications or third-party license fees are needed to use the content player. The player was developed in accordance with the cmi5 specification and supports the "proxying" of xAPI data between an AU and the xAPI conformant LRS. The player is not an LMS replacement. It functions as a cmi5 content player that can be included within an LMS when combined with an LRS and the components necessary to meet the cmi5 functional requirements. The LMS will need to meet the following requirements that are defined in the cmi5 specification:

- Implement an LRS as defined in the xAPI specification.
- Implement course handling as defined in Section 6.1.
- Implement the runtime launch interface as defined in Section 8.0.
- Implement additional xAPI "Statement API" requirements as defined in Section 9.
- Implement additional "State API" requirements to initialize the AU state as defined in Section 10.
- Implement additional xAPI "Agent Profile API" requirements as defined in Section 11. (AICC, n.d.)

The open-source cmi5 content player prototype integrates with the Total Learning Architecture (TLA) Reference Implementation located within the TLA Sandbox by the ADL Initiative, which is part of a shared infrastructure for Federal and DoD organizations to test and evaluate their modernization strategies and components. The player can also be used as a standalone download or as a deployable instance on its own within an organization. The player provides support by playing a cmi5 course, meaning it launches a set of assignable units, and validates xAPI communications for cmi5 conformance. While the open-source cmi5 player prototype supports the CTS, it can also be utilized independently and extended to be used as a cmi5 player option across other applications (see Figure 4).

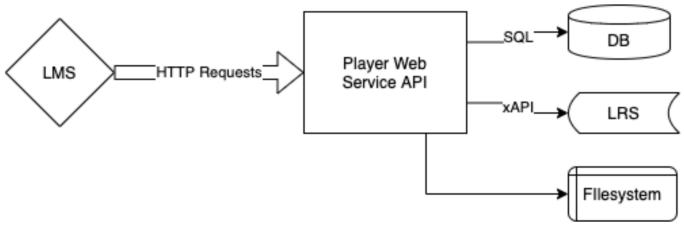

Figure 4. cmi5 Open-Source Content Player Prototype

cmi5 Course Templates

Project CATAPULT developed guidance and course templates to assist DoD organizations and industry publishers in migrating legacy SCORM-based content to the cmi5 and xAPI specifications. These course templates include information for a simple migration of completely browser-based SCORM content to more complex blended courses with a range of instructional activities. The templates focus on the methodology necessary for creating cmi5 courseware. The templates also include instructions for crafting cmi5 course content with the use of open-source libraries without an authoring tool. Once a course has been converted or created, content testers will want to test the course in the Content Conformance Test Suite to be sure it is conformant to the cmi5 specification.

Expected Outcomes

cmi5 is a critical component of the TLA vision and the DoD's emphasis on modernizing its Distributed Learning capabilities. These initiatives, coupled with the introduction of the Conformance Test Suites and exemplar content, will help accelerate cmi5 adoption rates across the DoD and federated platforms. The reason this acceleration can be confidently stated is because SCORM's diffusion was largely related to the release of the SCORM Test Suite, Sample Run-Time Environment, and Content Examples. Adoption success will come in the form of increased number of cmi5 Statements in DoD LRSs and increased number of DoD vendors supporting cmi5 in their products.

CONCLUSION AND FUTURE WORK

The future of learning and training is evolving. New technologies, like simulations and virtual reality, are playing a vital role in training initiatives across the DoD and governmental agencies. The legacy SCORM standard ensured plug and play interoperability of browser-based courses, but it is not extensible enough to track new and emerging technologies. The visions of ADL's TLA and DoDI 1322.26 address the need for more modern standards and define specifications and policies for enabling and implementing these new learning activities.

cmi5 and xAPI are two components in the larger modernization picture of moving to the concept of a learning ecosystem that supports a lifelong learning model and addressing the need for a standardized way to share data with other learning systems, including LMSs. The cmi5 specification and the tools recently introduced with Project CATAPULT play fundamental roles in ensuring that the vision of the TLA and DoDI 1322.26 become realized.

The next steps to ensuring that these two modernization efforts come to fruition are promoting the use of the cmi5 specification, creating cmi5 conformant content and systems, and reviewing cmi5 adoption rates across the DoD and federated platforms. The cmi5 Content Test Suite (CTS), cmi5 LMS Test Suite (LTS), and cmi5 Player Prototype were scheduled for release in the fall of 2021. A few ways that future work could follow and determine the rate of adoption of cmi5 are recording the number of cmi5 Statements in DoD LRSs, reviewing the number of DoD vendors offering tools that are cmi5 conformant, and monitoring the number of cmi5 courses and systems that are tested in the ADL-hosted versions of the conformance test suites. Increases in these objectives will signal a rise in the acceptance of the cmi5 specification.

REFERENCES

Advanced Distributed Learning Initiative, (2006). *Sharable Content Object Reference Model (SCORM)® 2004 3rd Edition Overview Version 1.0.* Retrieved April 27, 2021. https://adlnet.gov/assets/uploads/SCORM.2004.3ED.DocSuite.zip

Advanced Distributed Learning Initiative, (n.d.). *SCORM® Overview*. Retrieved April 20, 2021. https://adlnet.gov/projects/scorm/

Advanced Distributed Learning Initiative, (n.d.). *Experience API (xAPI) Standard*. Retrieved April 29, 2021. https://adlnet.gov/projects/xapi/

Advanced Distributed Learning Initiative, (n.d.). *xAPI Profiles*. Retrieved May 18, 2021. https://github.com/adlnet/xapi-profiles

Advanced Distributed Learning Initiative, (n.d.). *An Introduction to cmi5: Next-generation of e-Learning Interoperability*. Retrieved May 3, 2021. https://adlnet.gov/resources/cmi5-resources/

Advanced Distributed Learning Initiative, (n.d.). *cmi5 Specification*. Retrieved May 21, 2021. https://adlnet.gov/projects/cmi5-specification/

Advanced Distributed Learning Initiative & U.S. Department of Defense, (2013). *Experience API Specification.* Retrieved April 28, 2021. https://github.com/adlnet/xAPI-Spec/blob/master/xAPI-About.md

Aviation Industry Computer-Based Training Committee, (n.d.). *The cmi5 Project Overview.* Retrieved May 4, 2021. https://aicc.github.io/CMI-5_Spec_Current/

Aviation Industry Computer-Based Training Committee, (n.d.). *SCORM vs cmi5 Comparison.* Retrieved May 21, 2021. https://aicc.github.io/CMI-5_Spec_Current/SCORM/

Aviation Industry Computer-Based Training Committee, (n.d.). *xAPI/TinCan Package vs. cmi5 Comparison.* Retrieved May 21, 2021. http://aicc.github.io/CMI-5_Spec_Current/tincan/

Aviation Industry Computer-Based Training Committee, (n.d.). *cmi5 Specification Profile for xAPI.* Retrieved May 28, 2021. https://github.com/AICC/CMI-5_Spec_Current/blob/quartz/cmi5_spec.md

Bohl O., Scheuhase J., Sengler R., & Winand U., (2002, Dec. 3). *The sharable content object reference model (SCORM) - a critical review*. International Conference on Computers in Education, Auckland, New Zealand.

Johnson, A. & Hruska, N. [Advanced Distributed Learning Initiative]. (2013, Jan. 24). *The Experience API origins and capabilities webinar* [Video]. Streaming Service. https://www.youtube.com/watch?v=e8EDnoasTAg&t=361s

Johnson, A., Miller, B., & McDonald, B. [Advanced Distributed Learning Initiative]. (2021, Mar.17.) *cmi5 Overview and The Way Ahead webinar.* [Video]. Streaming Service. https://youtu.be/JSIXnw3hoOg

Office of the Under Secretary of Defense for Personnel and Readiness. (2017). *DOD Instruction 1322.26 Distributed Learning (DL)*. Department of Defense. https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132226_dodi_2017.pdf?ver=2017-10-05-073235-400/home_new

SCORM.com, (n.d.). *SCORM Explained 101: An introduction to SCORM*. Retrieved April 20, 2021. https://scorm.com/scorm-explained/one-minute-scorm-overview/

SCORM.com, (n.d.). *Evolution of SCORM*. Retrieved April 21, 2021. https://scorm.com/scorm-explained/business-of-scorm/scorm-versions/

Werkenthin, A. (2015, May 21). *Experience API, cmi5, and Future SCORM*. Learning Solutions Magazine. https://learningsolutionsmag.com/articles/1697/experience-api-cmi5-and-future-scorm

xAPI.com, (n.d.). *xAPI Explained: Overview.* Retrieved April 30, 2021. https://xapi.com/overview/