Learning Technology Standards - the New Awakening

Dr. Robby Robson[1] **Avron Barr[2]**
Eduworks Corporation[1] IEEE Learning Technology Standards Committee[2]

INTRODUCTION

Standardization has been a lynchpin of industrialization. It is hard to imagine railroads, automobiles, electric grids, or the Internet without standards for rail gauges, oil viscosity, voltages, internet protocols, and thousands of other things. Organizations such as the International Organization for Standardization (ISO) and IEEE Standards Association (IEEE-SA) have published thousands of standards ranging from highly technical standards that define the inputs and outputs of systems to process and quality standards designed to ensure that goods are produced in a repeatable, auditable fashion.

Yet, within any given discipline or area, the rate and quantity of standardization is often cyclic. The field of learning technology is no different and is currently in the middle of a surge. The years 2017 and 2018 have seen the establishment of new standardization efforts in the areas of competencies, credentials, virtual reality, eBooks, data privacy, learning pathways, and adaptive instructional systems (AIS). This paper examines the forces that have led to this surge, suggests that *learning portability* is the new problem that is the driving force behind this new awakening, and discusses this in the context of efforts launched by the US Army Research Laboratory GIFT project (Sottilare et. al., 2012) to develop standards for AIS.

Disclaimer: *The views expressed in this paper, including characterizations of standards and standards development organizations, are those of the authors and should not be interpreted as representing the views of any organization.*

INTEROPERABILITY STANDARDS

The standards addressed by this paper are *interoperability standards.* Interoperability standards permit multiple systems or services to work together even if they were designed and manufactured by different vendors – potentially from in different countries and who speak and code in different languages.

As measured by adoption and incorporation into products, *interoperability standards typically succeed because they solve a market-relevant problem*, usually a problem related to supply chains, the cost of production, or market expansion. It is an instructive exercise to think of familiar standards and then to identify the problems they solved and the impact they have had. Standards for weights and measures, for example, solved the problem of parts being produced separately and still fitting the devices that used them. This capability was a pre-requisite for the industrial revolution. The Domain Name System (DNS), as another example, enabled users to refer to servers by names they could remember rather than by meaningless strings of numbers. This convenience was vital to the early growth of the Internet.

Disruptive innovations and technical breakthroughs often lead to new interoperability problems and hence to surges in standardization. Disruptions include new inventions (the steam engine or personal computer), new processes (the assembly line), or new business conditions (the Software-as-a-Service business model). Once these have played out in the market, however, there is often a reduction in the number of high value interoperability problems that must be addressed, so one expects a corresponding reduction in standards activity. This explains the cyclic nature of standards activities mentioned in the introduction and suggests that increases in standardization are often triggered by innovations. Identifying and understanding these innovations can help standards development organizations (SDOs) determine which proposed standards are most likely to have an impact.

Conceptual Interoperability Standards

In software, most interoperability standards address data formats, communications protocols, and system requirements, but there is another type of interoperability that might be termed *conceptual interoperability*. Conceptual interoperability includes shared vocabularies, system architectures, frameworks, and reference models that help producers and consumers communicate effectively. A well-known example is the Open Systems Interconnection (OSI) model developed as the ISO 35.100 series of standards in the 1970s (Wikipedia, 2018). OSI defines the network layers (physical, data link, network, transport, session, presentation, and application) that are used in product manuals, purchasing requirements, engineering courses, and many other places.

As illustrated by OSI, conceptual interoperability standards can stimulate markets. However, for this to occur, there must be a market in place and that market must be experiencing a communication problem. The learning technology field, in contrast, has tended to create conceptual interoperability standards well in advance of the development of markets for the systems they conceptualize. Such standards, while useful for research and academic purposes, rarely have a significant effect on products, consumers, or end-users.

LEARNING TECHNOLOGY STANDARDS (1997 – 2009)

In the view of the authors, the innovation that spurred the development of the first wave of learning technology standards was the web and publicly available web browsers. This led to online and web-based courses and to what is now called "eLearning." The fundamental interoperability problem that plagued the early eLearning market was **content portability.** At first, the functionality of content depended on the features and functionality of the specific system that delivered it, usually some type of learning management systems (LMS). This market issue had significant economic impact: Organizational consumers were locked into their LMS, and there could be no general eLearning authoring tools or mass-market content distribution, since instructional designers and developers had to develop content for a one LMS at a time.

A wave of standards emerged from c. 1997 – 2009 that separated content from its delivery mechanism. These included:

- Aviation Industry CBT Committee (AICC) set of Computer Managed Instruction (CMI) standards;
- IMS Global Learning Consortium (IMS) Content Packaging and Question and Test Interoperability (QTI) – which was derived from a specification called Question Markup Language (QML) contributed by Questionmark (Questionmark, 1997) – and Common Cartridge standards;
- The IEEE Learning Technology Standards Committee (LTSC) standards for Learning Object Metadata and "Content Object Communication" (derived from the AICC CMI standard) and

- The Shareable Content Object Reference Model (SCORM) published by the Advanced Distributed Learning (ADL) Initiative, which adopted standards from both the IMS and the IEEE LTSC to define a procurement requirement for LMSs and content that ensured interoperability.[1]

These standards catalyzed the growth of a multi-billion-dollar industry (Reuters, 2017) that includes LMS vendors; a variety of eLearning authoring tools (ranging from "rapid eLearning tools" to products such as Authorware™ and Learning Content Management Systems (LCMS)); and both mass-market publishers and bespoke eLearning development companies. The SDOs listed above created many other eLearning standards as well – including standards for competency definitions, learner profiles, architectures, learning systems design, digital rights management – but none of these achieved the same level of adoption as basic content portability, presumably because none of these addressed a pressing market need.

THE NEXT WAVE: ENABLING A SUPPLY CHAIN (2010 – 2016)

The LMS was invented at the time when the prevailing model of the web was as a content delivery system. As the web evolved to a networking tool characterized by social media and eCommerce, learning technology standardization activities related to content portability predictably subsided and work started to focus on specific eLearning supply chain problems. The most active development during this period came from the IMS Global Learning Consortium, which describes itself as serving a "community of educational institutions, suppliers, and government organizations" (IMS Global Learning Consortium, 2018a). From a standards perspective, this constitutes an eLearning supply chain that runs from academic publishers to educational institutions to students via LMSs and associated technologies. IMS Global standards released between 2010 and 2016 included (IMS Global Learning Consortium, 2018b):

- Standards for the accessibility of content by learners with have special needs or are in problematic environments (such as in poorly lit environments or on noisy airplanes), many of which were based on prior work of the accessibility community (IMS Global Learning Consortium, 2012);
- Updates to its Common Cartridge and Question and Test Interoperability standard; and
- A Learning Tools Interoperability standard that originally focused on plugging tools into an LMS but via several updates has been generalized to enable sharing content, user management services, and "launch" messages among tools;

These standards address important problems in the learning delivery ecosystems maintained by institutions and the supply chain that supports them. They improve interoperability and make the sharing of data, services, and tools within each ecosystem more efficient. However, they do not address any problems that are fundamentally different from those addressed by the first wave of content portability standards.

Another significant pre-2017 standards release was the ADL's Experience API (xAPI) (ADL Initiative, 2018). First released in 2013, xAPI focuses on reporting and sharing the outcomes of learner activities. Developed and branded as "tin can" by Rustici Software, xAPI was incorporated into Rustici's SCORM engine and SCORM Cloud. This led to immediate adoption, but largely as a substitute for the reporting mechanisms in SCORM. The ADL's initial vision of xAPI may have included innovations such as integration into the Internet of Things (IoT) and supporting a new wave of learning analytics, but as applied, it primarily overcame constraints imposed by SCORM in the corporate (and military) eLearning supply chain.

[1] SCORM achieved an unprecedented level of global adoption, in part because one vendor, Rustici Software, provided services that allowed all LMS vendors to implement SCORM consistently and cost effectively.

Other Standards Activities

IMS Global and the ADL were not the only organizations developing learning technology standards and specifications during this period. The IEEE LTSC lay largely dormant but released a Resource Aggregation Model for Learning Education and Training (RAMLET) standard that defines a conceptual model for expressing aggregations of digital learning resources as ontologies and applies this to a variety of other standards, ranging from IMS Content Packaging to the Metadata Encoding and Transmission Standard (METS) (Library of Congress, 2018). ISO/IEC JTC1 SC36, also known as ITLET ("Information Technology for Learning Education and Training"), has published 39 standards documents, including many in the period in question. These range from adoption and adaptations of IEEE LTSC and IMS Global standards to standards that address e-portfolios, learning analytics, competency, virtual experiments, collaborative workplaces, and requirements for e-textbooks.

ITLET standards and RAMLET are primarily conceptual interoperability standards. They consist of abstract frameworks and reference models that identify components of systems architectures and data models but do not define concrete Application Programming Interfaces (APIs) or data formats. They may, of course, prove useful in the future – for example, a new generation of intelligent agents may successfully reason about real-world phenomena using the ontologies defined by RAMLET. Nonetheless, the IEEE or ITLET standards developed prior to 2016 appear to have had little impact on learning technology products. The base RAMLET conceptual model, for example, had a total of 166 fulltext views from IEEE Xplore as of April 2018, whereas the IEEE Learning Object Metadata data model – released the same year – had almost ten times as many (1640) such views, despite being freely and easily available in multiple places on the web (IEEE Xplore, 2018a and 2018b).

CHANGE FACTORS

Until very recently, almost all learning technology standards that achieved adoption in the marketplace focused on concrete interoperability problems associated with the models of eLearning that were established in the early days of the web. These models have undergone refinement and evolution but not revolution, which has often frustrated researchers and technologists (including the authors). From the very start, these innovators envisioned the web as a means to radically transform education and training from a didactic endeavor dominated by classroom lectures into something completely new that is personalized, immersive, intelligent, and far more effective. For example, in 1999, Robson wrote (Robson, 1999):

> "Once the content of WWW (sic) pages can interact with other types of records, it is possible to design systems in which content and even the functionality of the interface adapts to the record and preferences of the user and can be easily edited by an instructor or author. Communication could be managed in new and interesting ways not widely used in the university classroom. Authentic scenarios, role playing, virtual realities … all of these could support and could interact with other parts of the on-line learning environment."

Many of the research community's hopes and visions were reflected in conceptual standards or in standards that codified a specialized technical approach. Retrospectively, these had very little chance of being adopted for a variety of reasons, ranging from their lack of real-world market relevance to their overly complex nature that made them impractical to implement. More recently, however, there has been a new awakening, characterized by greatly increased interest and collaboration across multiple relevant industry and government sectors and by a focus on a new set of standards that do not involve content portability. In the view of the authors, the root cause of this awakening lies in the several disruptions that are outlined in this section.

Power to the People!

Over the past decade, social media, online video (YouTube), and increases in possibilities for real-time networking and communication gave rise to MOOCs and other technologies that incorporated connectivism and social constructivist theories of learning (Siemens, 2014), but the ability of learners to network with each other did not fundamentally change the nature of learning content or learning technology. The maturation of eCommerce and the spread of online courses did, however, trigger changes that are having a profound long-term effect on the education and training marketplace. What was once a world of disconnected, institution-bound opportunities from which a learner could select at most one at any given time has gradually become a supermarket that offers multiple concurrent choices. This development has created a consumer market that is shifting buying power and power over the curriculum from institutions to individuals.

Content portability standards benefit institutions by increasing the efficiency of their supply chains, but they do not prevent institutions from locking learners into their LMS, HR, or registrar system. Individuals, on the other hand, have a vested interest in ensuring that they can seamlessly move from one system to another – and receive the outcomes and credentials they seek – regardless of which systems they use or from whom they obtain their education or training. This is creating a demand for sharing data about learner preferences, backgrounds, traits, and achievements across learning systems and across institutional and content provider boundaries – a demand that will only grow with increasing global availability of online opportunities, the "gig economy," and labor market pressures to facilitate frequent re-training and career changes.

Power to the Technology!

The demand to share new types of data does not only come from market shifts. It is also being amplified by technology drivers, creating a perfect storm of change agents.

- **Cloud-based Web Apps:** The first technology driver is the shift from desktop applications to cloud-delivered web applications. Learning activities are increasingly delivered as web apps running on cloud servers. In this model, content is once again tied to delivery systems, but the web browser has become a standardized and ubiquitous player that works for any cloud-based activity, so content portability is no longer a market problem. At the same time, enterprise cloud applications typically communicate with each other as "services" that exchange relevant data behind the scenes. The relevant data are those that enable learners to transition seamlessly among learning activities and that enable the learning activities to adapt to the learner.

- **The Data Storm:** The second technology driver is the expansion of learning platforms to include mobile phones, tablets, and virtual/augmented reality devices *and the instrumentation of learners with devices that measure their location, movements, biometrics, and instant-by-instant actions.* These platforms *and devices* drastically increase the variety, velocity, and volume of data that is produced by and required by learning systems, a phenomenon that is closely coupled with the third technological driver, which is the emergence of artificial intelligence (AI).

- **Artificial Intelligence:** AI is being applied to education and training in many forms, including machine learning, educational data mining/learning analytics, and natural language processing. The combination of AI with the increasing availability of location, motion, visual, biometric, and other real-time data – not just from a single learner but from all learners in a learning ecosystem – makes it feasible to develop adaptive instructional systems (AIS) that are active participants in the learning experience. These systems are already posing questions that standards are suited to address, ranging from data and protocol interoperability to questions of privacy, data protection, and the transparency of AI systems' reasoning (Rozenfeld, 2017).

THE STANDARDS RESPONSE

The learning technology standards community is responding to these forces for change:

- The IEEE LTSC is now running several standards activities that have active participation from dozens of companies. The last time that this happened was over 15 years ago, during the early days of the AICC, IEEE LTSC, IMS Global, and ITLET.
- An IEEE Standards Association activity associated with learning technology – the Industry Connections Industry Consortium on Learning Engineering (ICICLE, 2018) – was launched in January of 2018. Its premise is that a cadre of specifically-trained professional engineers will be required to design and support future learning environments. ICICLE had 259 participants, 65 organizations/entities, and nine active special interest groups as of 23 April 2018, less than four months later.
- The IMS Global Learning consortium took over the Open Badge Alliance from the Mozilla Foundation on January 1, 2017 (Badge Alliance, 2017) and is also involved in standards for the exchange of competencies, academic standards, and learning pathways.;
- The Learning Resource Metadata Initiative (DCMI, 2018) and the Credential Engine (Credential Engine, 2018) are focusing efforts on Schema.org, which is an effort supported by the Google, Yahoo, and Yandex search engines;
- An ongoing joint effort started in 2017 is focusing on standards for competencies and credentials. This effort involves multiple standards development groups that represent HR, medical education, corporate training, and formal education;
- Standardization efforts in the eBook-for-education arena are taking place within the IEEE LTSC, ISO/IEC JTC1 SC36, and IMS Global in conjunction with the W3C Publishing Business group that was formed by the merger of the International Digital Publishing Forum (IDPF) with the W3C.
- The US Army Research Laboratory, which has been the home to many activities in Intelligent Tutoring Systems, has launched the Center for Adaptive Instructional Science and is working within the IEEE LTSC to explore related standards. (ARL, 2018)

Many of the above initiatives involve the standardized exchange of data about individual learners. These data range from granular activity reporting to data about learner competencies, preferences, traits, goals, and credentials (including formal credentials and micro-credentials represented by badges). These data are essential for AISs and for AI applications and are important for recruiting, staffing, talent management, and many other activities that intersect strongly with learning technology. Data standards in these fields are being embraced by public-private partnerships (U.S. Chamber of Commerce, 2018), lending added impetus and visibility to the standardization efforts listed above.

THE NEW PROBLEM: LEARNING PORTABILITY

The driving force behind many of these standards is the requirements that the learning experienced by an individual be portable across education, training, HR, staffing, talent management, career guidance, college admissions, and similar systems. In addition, AIS need previously generated learning data to make adaptations, and AI algorithms need to be trained on sufficiently large collections of such data from target populations. All these requirements involve what might best be termed *learning portability*, which extends to the portability of data generated by new learning platforms, e.g. eBooks, VR/AR, advanced forms of simulations, serious games, and AIS. The standards being developed for these platforms are less concerned with the ability to move content across them as the with the ability for these platforms to exchange learner data using standardized data services.

PLUS ÇA CHANGE, PLUS C'EST LA MÊME CHOSE

Many learning portability standards projects are continuations of projects started long ago, some before 2000. These include standards ranging from competency and credentialing standards to standards for agent interoperability. The difference is that earlier standardization attempts were conceptual or focused on point solutions developed by small groups or single organizations. At their core, they addressed pedagogical problems rather than business and market problems. This relegated learning technology standards to a sleepy corner of the fast-moving world of digital information and communication technology (ICT).

In one respect, things are now different. The forces for change outlined earlier have brought learning technology interoperability into greater alignment with other ICT issues, while changes in business models and in the power relationship between individuals and institutions are disrupting all education and training market segments on multiple fronts. This combination has awoken the industry to the value and need for a new set of learning technology standards, just as the requirement for content portability did during the last wave of standardization. Nonetheless, there is still a propensity for the learning technology standards community to believe that its mission is to radically improve learning. It may turn out that this works out well as pedagogical problems converge with market problems, but without injecting a keen awareness of the need for market, business, and technological relevance into the standards development process, it is also likely that many standards will be produced that experience low adoption rates.

WHAT THIS MEANS FOR AIS

The context of this paper is an effort being led by the Army Research Laboratory and the GIFT project, to explore standards for AIS. In this context it is important to observe that intelligent tutoring systems (ITS) and other AIS have until recently been self-contained systems designed for desktop use. ITS were developed in response to Bloom's work on the effectiveness of various modes of instruction that concluded that one-on-one tutoring could realize a two-sigma increase in learning effectiveness over classroom instruction (Boom, 1984) Modeling this form of instruction requires computational power and user interactions that until recently could only be realized using specialized software running on dedicated devices, mostly on desktop computers. These monolithic systems, including GIFT and commercial systems such as Knewton and Carnegie Learning's tutors, have been small players in the learning technology marketplace (Robson & Barr, 2013) and are not part of the eLearning supply chains addressed by standards.

In addition, the general problem of content portability for AIS seems too complex for standards. Attempts to standardize representations for adaptive content, which arguably include the more complex portions of SCORM's simple sequencing and standards such as IMS Learning Design (IMS Global Learning Consortium, 2013), have proved to be problematic and have not been adopted – and these efforts only scratch the surface of what it would truly mean to have plug-and-play representations of the learning experience delivered by a sophisticated AIS. The problem is that AIS are not about content at all but instead are about guiding a learner through a set of experiences in a personalized manner, which differs radically from the traditional "web as a delivery system" model that is reflected in most content portability standards.

The new problem of *learning portability*, in contrast to content portability, is more aligned with AIS. From the perspective of the learner, the knowledge or skills or credentials gained from an AIS are no different than those obtained from any other system. From the perspective of an AIS, domains and data on a learner's state should be independent of the algorithms it uses. Moreover, as ITSs such as GIFT move to the cloud, they become more capable of exchanging and consuming data of the type associated with the new wave of learning technology standards through standardized APIs. It is therefore reasonable to expect that judiciously developed and adapted learning portability standards can bring AIS into the mainstream of learning technology ecosystems. As a benefit, the will reduce the cost of developing and deploying AIS while providing their proprietary AI algorithms with the data they need to perform better and better adaptations and to improve their effectiveness as learning systems.

REFERENCES

ADL Initiative. (2018). The xAPI Overview. Retrieved 28 April 2018 from https://www.adlnet.gov/research/performance-tracking-analysis/experience-api/.

ARL. (2018). Center For Adaptive Instructional Sciences (CAIS). Retrieved 04 May 2018 from https://www.arl.army.mil/opencampus/?q=centers/cais

Badge Alliance. (2017). The Badge Alliance is now part of IMS Global Learning Consortium. Retrieved 04 May 2018 from http://www.badgealliance.org/

Bloom, B. S. (1984). The 2-sigma problem. *Educational Researcher*, 13(6), 4-16.

Credential Engine. (2018). Credential Engine web site. Retrieved 29 April 2018 from http://www.credentialengine.org/

DCMI. (2018). LRMI Terms. (Learning Resource Metadata Initiative). Retrieved 06 May 2018 from http://dublincore.org/dcx/lrmi-terms/

IEEE Xplore. (2018a). 1484.12.1-2002 - IEEE Standard for Learning Object Metadata. Retrieved 29 April 2018, from https://ieeexplore.ieee.org/document/1032843/

IEEE Xplore. (2018b). 1484.13.1-2012 - IEEE Standard for Learning Technology -- Conceptual Model for Resource Aggregation for Learning, Education, and Training. Retrieved 29 April 2018 from https://ieeexplore.ieee.org/document/6228480/

IMS Global Learning Consortium. (2012). MS Global Access for All (AfA) Primer. Version 3.0 Specification, Public Draft 1.0. Retrieved 06 May 2018 from https://www.imsglobal.org/accessibility/afav3p0pd/AfAv3p0_SpecPrimer_v1p0pd.html

IMS Global Learning Consortium. (2013). Learning Design Specification. Retrieved 06 May 2018 from http://www.imsglobal.org/learningdesign/index.html

IMS Global Learning Consortium. (2018a). About the IMS Global Learning Consortium. Retrieved 28 April 2018, from https://www.imsglobal.org/aboutims.html.

IMS Global Learning Consortium. (2018b). Download IMS Interoperability Standards. Retrieved 28 April 2018, from http://www.imsglobal.org/specifications.html.

ICICLE. (2018). ICICLE web site. Retrieved 29 April 2018, from https://www.ieeeicicle.org/.

ISO. (2018). Standards Catalog for ISO/IEC JTC1 SC36. Retrieved 29 April 2018 from https://www.iso.org/committee/45392/x/catalogue/p/1/u/0/w/0/d/0.

Library of Congress. (2018). METS Website. Retrieved on 29 April 2018 from http://www.loc.gov/standards/mets/.

Questionmark. (1997). QML (Question Mark-up Language) Overview 0.9.5. Retrieved 06 May 2018 from https://www.questionmark.com/sites/default/files/PDF/overview.doc.

Reuters. (2017). Global E-Learning Market 2017 to Boom $275.10 Billion Value by 2022 at a CAGR of 7.5% – Orbis Research. Retrieved 29 April 2018 from https://www.reuters.com/brandfeatures/venture-capital/article?id=11353.

Robson, R. (1999). WWW-based course-support systems: The first generation. *International Journal of Educational Telecommunications,* 5(4), 271-282.

Robson, R., & Barr, A. (2013). Lowering the Barrier to Adoption of Intelligent Tutoring Systems through Standardization. Design Recommendations for Intelligent Tutoring Systems: Volume 1-Learner Modeling, 7 - 13.

Rozenfeld, M. (2017). Seven IEEE Standards Projects Provide Ethical Guidance for New Technologies. *The Institute,* 5 May 2017. Retrieved 28 April, 2018 from http://theinstitute.ieee.org/resources/standards/seven-ieee-standards-projects-provide-ethical-guidance-for-new-technologies.

Siemens, G. Connectivism: A learning theory for the digital age. *International journal of instructional technology and distance learni*ng, 2(1) (2005), 3-10.

Sottilare, R., Brawner, K., Goldberg, B. & Holden, H. (2012). The Generalized Intelligent Framework for Tutoring (GIFT). US Army Research Laboratory.

U.S. Chamber of Commerce. (2018). U.S. Chamber Foundation to Develop Job Registry Project with Support from Google.org and JPMorgan Chase & Co. Retrieved 29 April, 2018 from https://www.uschamberfoundation.org/press-release/us-chamber-foundation-develop-job-registry-project-support-googleorg-and-jpmorgan

Wikipedia. (2018). OSI model. Retrieved April 29, 2018 from https://en.wikipedia.org/wiki/OSI_model.

ABOUT THE AUTHORS

[1]***Dr. Robby Robson*** *is co-founder and CEO of Eduworks. He is a long-time contributor to learning technology research, products, and standards who has held leadership positions in multiple standards development organizations including the IEEE Learning Technology Standards Committee, the IMS Global Learning Consortium, ISO/IEC JTC1 SC36 (Information Technology for Learning, Education, and Training), and the Learning Resource Metadata Initiative. His current focus outside of standards is the development of global infrastructure for competency-based education and training – see www.cassproject.org.*

[2]***Avron Barr*** *started his career as an editor of The Handbook of AI (a seminal 3-volume book on Artificial Intelligence) and a founder of Teknowledge, an early AI startup. Since Teknowledge was sold in 1986, he has been an independent consultant in Silicon Valley, helping innovators understand, explain, and market technologically-advanced software. He currently consults for the Institute for Defense Analyses, helping evaluate the US Advanced Distributed Learning (ADL) Initiative's Total Learning Architecture, and is serving as chair of the IEEE Learning Technology Standards Committee.*