



CEMCA

EdTech *notes*

A topical start-up guide series on emerging topics on Educational Media and Technology

Experience API (xAPI): Potential for Open Educational Resources



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Introduction

In the past, Sharable Content Object Reference Model (SCORM) had been the most successful learning standard in recording learning activities within web-based training systems, but it was created prior to widespread use of other types of delivery platforms and learning environments such as mobile devices, intelligent tutors, virtual worlds, games, wearables, and social networking tools. For example, mobile learning is now a ubiquitous educational technology; it can accommodate both formal and informal learning, in collaborative or individual learning modes. These capabilities can augment the performance of today's learners, but the process cannot be tracked by SCORM. It is restricted to tracking specific course-oriented things such as lesson pages viewed, test scores, and module completions; the content must be managed through a Learning Management System (LMS).

“SCORM is a collection and harmonization of specifications and standards that defines the interrelationship of content objects, data models and protocols such that objects are sharable across systems that conform to the same model. This specification promotes reusability and interoperability of learning content across Learning Management Systems”

“SCORM is a collection and harmonization of specifications and standards that defines the interrelationship of content objects, data models and protocols such that objects are sharable across systems that conform to the same model. This specification promotes reusability and interoperability of learning content across Learning Management Systems (LMSs).” -from ADLnet.gov

SCORM is concerned with making contents portable between SCORM-compliant systems, but xAPI leaves any content residing anywhere it is and keeping any format it has, just records the experiences in a standard structure and language.

Outside of LMS environments, Innovative and diversified technologies are increasingly available for teaching and learning. Although this phenomenon creates richness, diversity, and creativity in learning experiences, it also results in

a serious problem — data silos. Digital learning generates data streams, and data is valuable for evidence-based learning design. But now they are locked in different tools, like thousands of puzzle pieces that can't be put together. There is a need for “the next generation of SCORM.”

Advanced Distributed Learning (ADL) is a Research & Development (R&D) initiative of Department of Defense(DoD) that began as a joint project of the US DoD and the Department of Labor (with industry participation). You may know ADL as the organization that brought us the SCORM standard. Around 2010, ADL recognized a need to define an updated standard that could overcome many of SCORM's inherent limitations. The paradigm shifts in training and learning led to the birth of **Experience API (xAPI)**, which allows us to pull data together from multiple tools, devices, applications, and systems, and will ultimately provide a more personalized learning experience.

XAPI works on the following premises:

- People learn from interactions with other people, contents, and tools. These actions can happen anywhere.
- When an activity needs to be recorded, the application sends secure statements in the form of <Actor><Verb><Object> (Fig.1), and additional details with <Result>, in <Context>, at <Timestamp>, with <Attachment>, to a Learning Record Store (LRS).
- LRSs record all of the statements made. An LRSs can share these statements with other LRSs, and can exist on its own, inside an LMS or inside a machine.

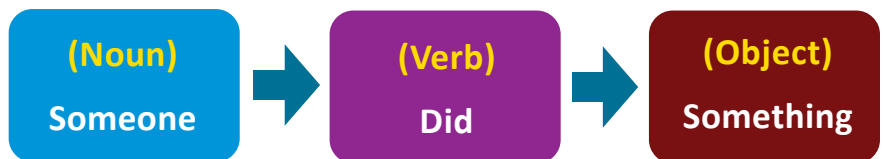


Fig.1: Minimum components of an xAPI statement

XAPI was initially based on the Activity Streams specification, which emerged from social networking and is used by sites such as Facebook, Twitter, and Google Plus. But more defined constructs were added for the storing and transferring records of learning experiences.

Activity Streams are already widely used in games and social platforms for tracking group/guild activities and for real time data gathering and analysis. An Activity Stream can be thought of as a triple. A triple is similar with an expression in the form of subject-predicate-object used in the Resource Description Framework (RDF) World Wide Web Consortium (W3C) specifications. RDF makes up the basic components of the Semantic Web, and is called a graph data model. The expression relates data together and the resulting relationships can be used to infer information through semantic analysis. A primary example of semantic analysis is how Google knows so much about us and the types of content we are seeking. This is significant for Learning Analytics. To be accurate, xAPI is not a graph database model, it is more of key-value store, but it can become the glue that bridges graph models with various types of NoSQL data. We'll talk more about this later.

Other significant meanings xAPI brings to us are:

- Granularized records and contextual information from widely-diversified environments, not just learning events, can be captured.
- Data storage and retrieval are independent of the applications that generated them. 3rd party reporting and analytics tools can integrate and re-use data from different LRSS.
- Human interactions in group learning, peer learning, social learning, and instructor-led learning can be recorded and interpreted.
- Like Activity Streams, the vocabularies are extensible and community-driven so the possibilities of learning design and tracking are limitless.
- This JSON (JavaScript Object Notation) - based standard language can work with different programming languages, and it is bandwidth-non-intensive and suitable for Internet of Things (IoT) applications.
- The focus of the learning standards has transferred from contents to experiences — interactions between learners and contents, activities, objects, and other roles.

The xAPI forms a building block for ADL's eventual goal: to create a "Personal Assistant for Learning" (PAL) that can understand learner needs and

provide personalized learning content at the right time. xAPI — learning experience tracking — is in fact the first cornerstone of the Training and Learning Architecture (TLA) that encompasses a set of standardized Web service specifications and Open Source Software (OSS) designed to create a rich environment for connected training and learning. Like SCORM, the TLA is not a system itself, rather enables systems or applications to be built for learning. The TLA capability supports ADL's Next Generation Learning Environment research and development strategy and is laying the foundation for PAL (TLA, 2012).

Assessment for Learning

Education is about deciding what students need to learn (the objective), about learning and teaching (content and activity), and about assessment (monitoring student progress and competency). Of the three, assessment has usually been the lagging factor in the past.

CTO of the Smarter Balanced Assessment Consortium Brandt Redd (2012) made an analogy of a learning system as a control system — "closed loop" is better than "open loop" and "negative feedback" is good while "positive feedback" is bad. Because students come to us with different personalities, talents, preferences, and backgrounds, without "negative feedback" the result will be out of control. A personalized learning system should look like a closed-loop control system. (Fig.2) For feedback to be really effective, it must be frequent, fast, and rich.

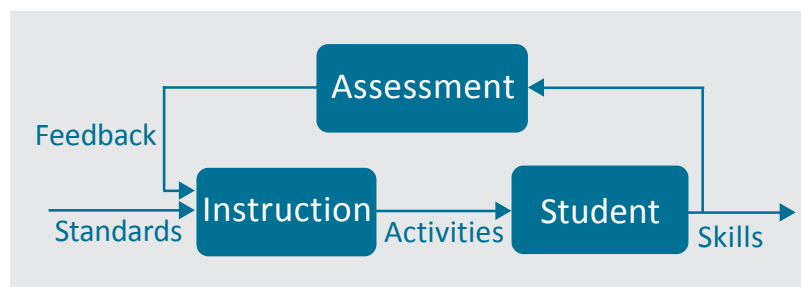


Fig.2: An education system with negative feedback (Redd, 2012)

Frequent, fast, and rich feedback depends on frequent, fast, and rich assessments. Now with the promise of recent digital learning technologies, it is finally possible.

There is no need to distinguish between learning activities and moments of assessment. Instead, a model of the learner's knowledge state is continually assessed and updated.

XAPI can be embedded in almost any digital learning system and workflow to probe a learner's behaviors in a non-intrusive way. It can reliably assess a wide range of outcomes and the learner's multifaceted attributes (habits, preferences, collaboration, dispositions etc.). There is no need to distinguish between learning activities and moments of assessment. Instead, a model of the learner's knowledge state is continually assessed and updated.

The information and analytics become real-time, authentic, and ongoing feedback to the learner and his instructor, and can be used to personalize learning paths automatically in an intelligent tutoring system. The aim of such a system is to facilitate self-paced learning without help from teachers — like a gamer progressing by trial and error as long as he is in the zone of proximal development (ZPD). Assessment for learning is for guiding the best next step to support students and teachers rather than measuring past achievement. It is crucial to measure what is important, not just what is easy to measure.

The “Actor” (learner) isn't just a puppet in a given story. They are characters in their own stories and in their peers' stories. Well-designed xAPI data can form meaningful feedback and aid for the learners themselves. An ipsative assessment (Hughes, Okumoto, & Wood, 2011) in an education/learning context compares a test-taker's results against his or her previous results. XAPI is helpful for both weak learners (so that they are not discouraged by comparison) and strong learners (to preventing complacency). With xAPI tracking, feedback comes not only from test results, but also behaviors related to study skills. This makes data loops work even before advanced analytics come into play.

Distributed Nature of OER

Open Educational Resources (OER) have already made a profound impact on education world-wide. The OER world map (<https://oerworldmap.org/>) displays OER around the world. Open licenses permit open collaboration to build and improve learning resources upon others' works with ease. Mashups and remixes from open-licensed

contents in multiple forms are common. Before customization, many digital learning materials did not match the requirements of different learners! With OER, educators can promote collaboration and provide customized resources for students. For example, the Floe (Flexible Learning for Open Education) project (<http://www.floeproject.org/>) provides resources needed to enable inclusive access to personally relevant, engaging learning opportunities for diverse learners and content producers. Through the Open Education Resources community, Floe makes tools that help transform, augment, and personalize the learning experience.

All open source efforts about open content and open source software have resulted in the distributed, diversified, and continuous growing nature of OER and open learning, including in content design, formats, contexts, tools, and platforms. It's impossible to be bounded inside any LMS. XAPI provides better data interoperability between different types of educational systems and devices.

Open Learning Analytics

Open Learning Analytics, an integrated and modularized platform, was proposed by SoLAR (Society for Learning Analytics Research) to build an open platform approach to integrate heterogeneous learning analytics techniques (Siemens *et al.*, 2011). It fundamentally requires an open platform with standards for adding new “plugins.” As long as developers of analytics, recommender services, visual user interfaces, and intervention strategies comply with these standards, their work can become part of this ecosystem. The open and extensible learning analytics platform aims to grow an ecosystem of stakeholders and tools around this. The concept of the platform and the community around it are depicted in Figure-3 (Shum, 2012).

In an interview at the Open Learning Analytics summit with Josh Baron, Baron pointed out that open standards like xAPI and Learning Record Store (LRS) can bring data from diversified sources into a single repository. After xAPI data are sent to any one LRS, they can be retrieved and aggregated by another LRS for analytics and reporting purposes. An open standard like xAPI makes the

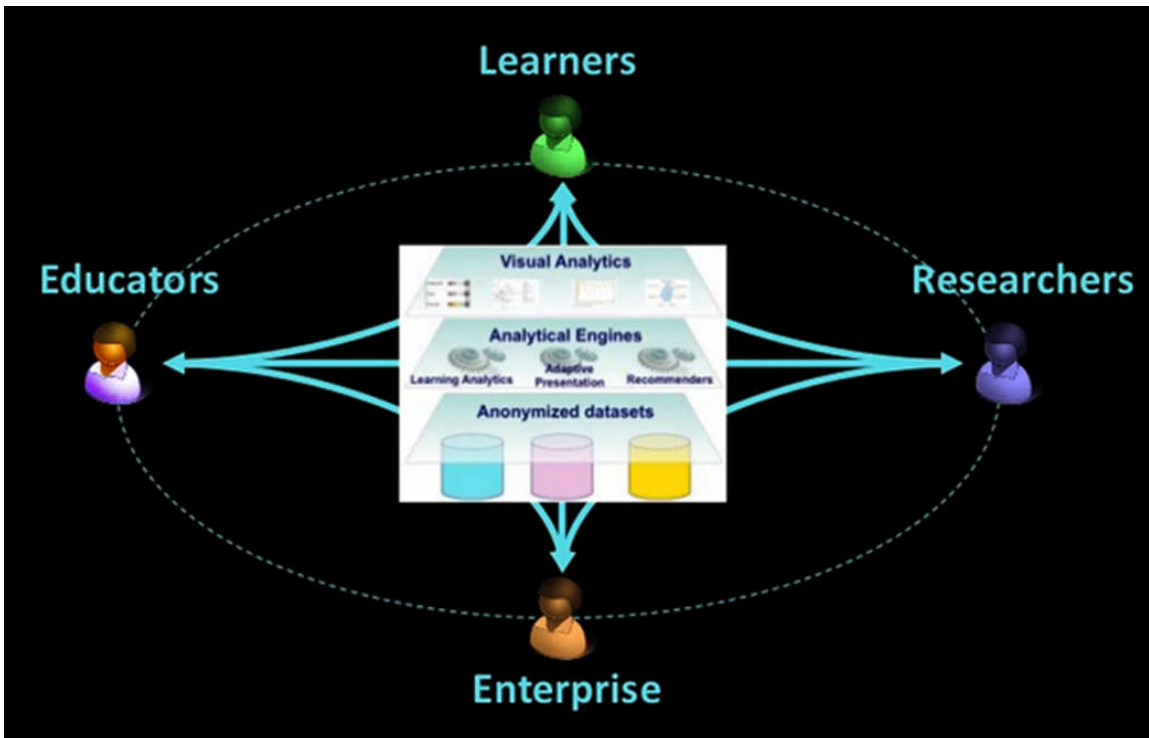


Fig. 3: Open Learning Analytics platform forms feedback loops to different roles (Shum, 2012)

Open Learning Analytics picture possible (Grush, 2014).

The United Kingdom non-departmental public body JISC have an initiative called **Effective Learning Analytics**. The Effective Learning Analytics challenge is about using data and analytics to support students; improving satisfaction, retention and graduation rates. The whole architecture, including a learning analytics processor, a staff dashboard, an alert and intervention system, a student app, and a learning records warehouse, is built upon using xAPI as the foundation for Open Learning Analytics (Sclater, 2015).

“Data is the 21st century’s new raw material.” said Rt Hon. Francis Maude, minister of the cabinet office and paymaster general, in the Foreword of the Open Data White Paper - Unleashing the Potential (Maude, 2012). Open Data is becoming an invaluable resource for research and scientific communities in many areas. Open sharing of anonymized learning data makes open collaboration on learning analytics research possible, and if the data from different sources are made interoperable, this will speed up the advance. “Open Data as OER” is a new initiative in the UK exploring the use of real world open data

in educational contexts, but “open silios” — for want of data interoperability — is the first barrier to the ideal (Campbell, 2015).

Linked Data for Open and Distance Learning

Mathieu d’Aquin (The Open University, UK) is one of the world’s leading experts in artificial intelligence. He had created a report “Linked Data for Open and Distance Learning” for the Commonwealth of Learning to utilize Semantic Web mechanism to help educators find the needle they want in the haystack of options (d’Aquin, 2014).

Linked data relies on the simple idea that the mechanics used nowadays to share and interlink documents on the web can be applied to share and interlink data and metadata about these documents, as well as the concepts and entities they relate to. On the Web of Linked Data, every “data object” (representing a person, a place, or a topic) is identified by a web address and characterised with web links that can

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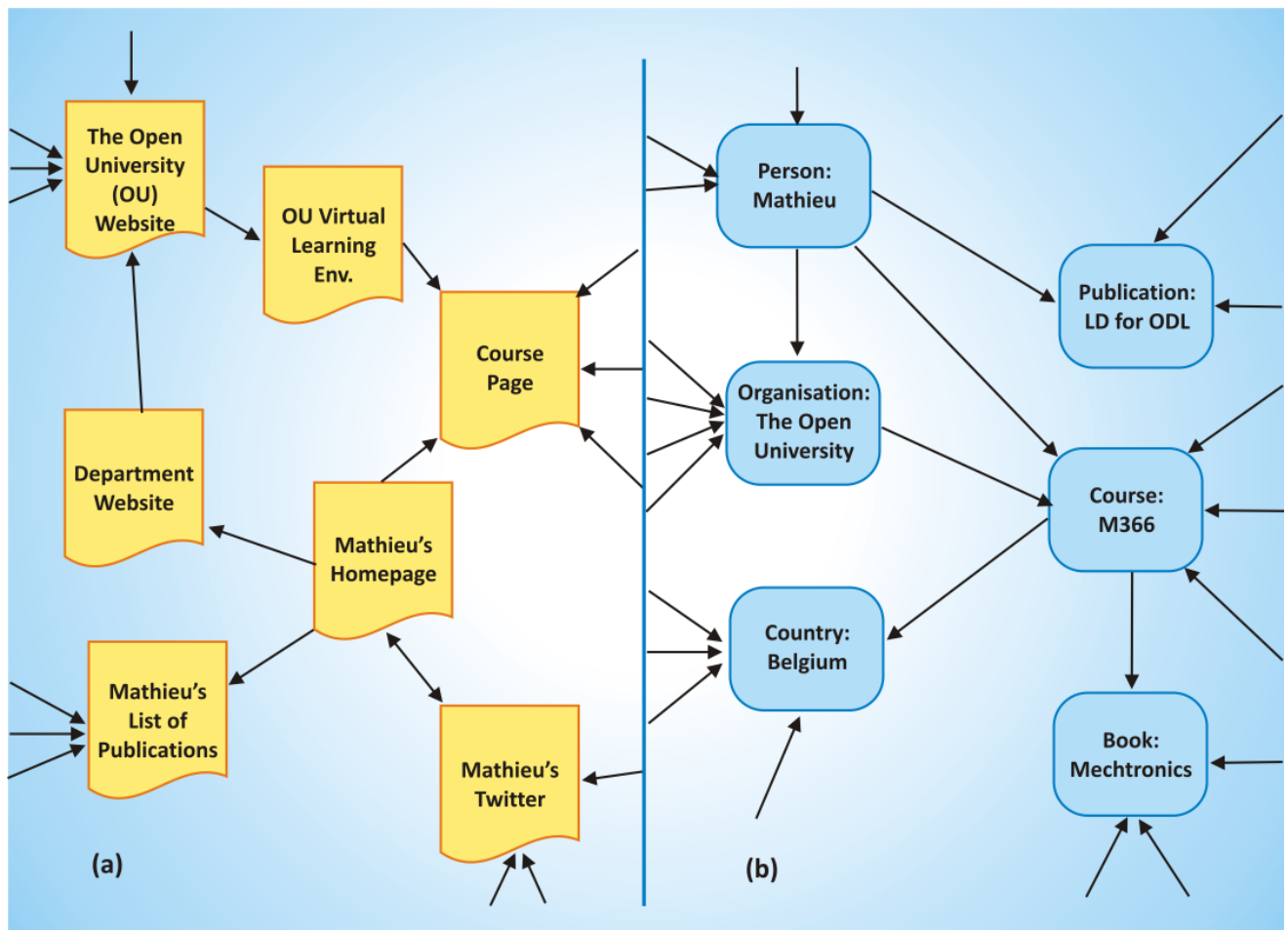


Fig. 4: The web as a network of interconnected documents (a); Linked data as a network of interconnected data entities (b) (d'Aquin,2014).

connect to representations of other data objects, identified by other Web addresses, thus using the web as a giant data graph that openly draws from any contributing source. (Fig. 4) The linked data approach enables building of an ecosystem of data where each individual provider contributes to a common, open and global network, rather than limiting themselves to a silo of information. Several Linked Data initiatives in education domains for OER and personalized learning development are underway.

Linked Data, frequently described as “the Semantic Web done right” by the Inventor of the World Wide Web Tim Berners-Lee (2009), has emerged as the de facto standard for sharing semantic data on the web. ADL technical team is currently working hard to add Linked Data/RDF support for anything in xAPI with an Internationalized Resource Identifier (IRI, a web address is the most common one) such as verbs, activity types, attachments, extensions etc.. By leveraging Linked Data as the foundation

for xAPI vocabularies, it could fundamentally improve the quality and semantic interoperability of xAPI data by allowing the vocabulary metadata to match schemas and interlink previously unrelated datasets. In other words, controlled vocabularies and ontology metadata for xAPI, if linked, could provide the semantic glue needed to make xAPI data become more expressive and reusable.(Haag, 2015) And, it could possibly open the door to artificial intelligence opportunities for xAPI.

Jason Haag from ADL technical team gave more elaboration to be quoted in this article: In terms of data interoperability, the core xAPI specification primarily addresses structural interoperability (the ability of two or more applications or agents to exchange information). This focus on structural interoperability was the top priority of the community in order to enable the integration of

learning experience data from diverse sources to any application or platform. In addition to structural interoperability, semantic data interoperability is needed to avoid duplication of vocabulary terms and for applications to meaningfully interpret the information being exchanged. In other words, without a semantic vocabulary model the xAPI specification requires more manual work to interpret, organize, aggregate, and generally do useful things with the data.

The ability to link data from diverse sources is a motivator for many projects, as different CoPs seek to take advantage of semantically rich data that was previously spread across disparate sources. By adopting W3C's RDF standard as the data model for xAPI vocabulary resources and their metadata, the xAPI specification can potentially gain a whole new level of precision for machine readability and semantic interoperability. Upon implementation of this vocabulary specification (and refinement of vocabulary publishing practices) the xAPI community will benefit from exciting new opportunities and capabilities. Ideally, a vocabulary model for xAPI will open up new doors for improved learning analytics, federated search, dynamic look-up of xAPI vocabulary data within authoring applications, improved discovery and reuse of xAPI vocabularies, multilingual translation, and some basic natural language processing capabilities.

Scholars doing social network analytics found that putting object nodes together with learner nodes can better reveal how interactions between persons happen, that's also how Facebook uses Open Graph in the social network. So there are a network of persons and a network of resources, xAPI connects these two networks through the <Verb>, and can help content recommendations for learners. One of the object sociality comes from usage, collective usages can suggest better resources for the same kind of learners automatically, other information in xAPI statements such as <Context> and <Result> data can be added into the recommender algorithm development.

Linked Data is to the xAPI standard age what Learning Object Metadata (LOM) was to the

SCORM age, only much better! According to Haag, representing ADL technical team, in near future ADL will provide some examples, practices, tools and requirements in the specification for adopters to follow.

The Importance and Potential of xAPI for OER

OER are widely used by non-profit organizations and initiatives trying to solve issues of education in poor and rural areas where the lack of learning resources and teachers are both serious problems. Some non-profit organizations bring volunteers to rural villages; however, the temporary teachers who barely know the learners won't ever be a stable solution for the issue. If xAPI is implemented in OER to collect learners' data no matter if they are in cities or in rural villages, then learner profiles and progresses can be built up in LRSs. XAPI tracking is possible in both online and offline mode; even the learning records of learners without the Internet can be cached and sent back to LRS whenever the devices are connected. The data could be utilized in several ways to help learners.

- Distant tutors can review data and give interventions and instructions to help individual learners according to their strengths and weaknesses. Those distant tutors could be retired teachers in other countries. Since all data will be accumulated, switching tutors will not be a problem.
- Learning paths of high performance learners can be identified and recommended to low performance learners with similar preferences and attributes.
- Through interacting with the same content or related linked content, it's possible to connect learners from different corners of the world naturally and efficiently to facilitate peer learning.
- Leveraging Learning Analytics and semantic

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analysis with Linked Data, an intelligent tutoring system can recommend appropriate OER and stimuli to learners according to the individual's status. An open education solution to support better independent-learning for more is possible!

In the past, the major limitation of Learning Analytics research is the small size of the data bound within the system generating the data. The small size limits the confidence level when applying to other systems and learners. OER implemented with xAPI can be openly utilized; interoperable learning data across ecosystems and countries can build up strong Learning Analytics research outcomes which can help all types of learners, whether they are in big cities or rural poor villages. The data size from xAPI-enabled OER usage could be very large because of the data sharing and interoperability.

domain due to the slower pace at which educational institutions adopt new technology. Here we share some case studies in the education domain.

- Dr. Glahn from International Relations & Security Network, Swiss Fed. Inst. of Technol., Zurich, Switzerland had integrated the concepts of xAPI in a mobile learning application, and the app uses learning analytics functions based on the collected data to inform the learners about their learning performance, to encourage them to actively use the app, and to orchestrate and sequence learning resources. (Glahn, 2013)
- The biggest pain for teachers using several pieces of technology and resources is putting together the workflow and data locked within different applications. The AcrossX solution, developed by Chuang (Classroom Aid Inc.) and Digital Education Institute (DEI), can solve this problem. The teacher can manage the learning plan as one activity, but leverage affordances and advantages from different tools and resources. (Fig.5) The xAPI data from different sources are integrated and visualized on the teacher's dashboard. The data are also leveraged to add a social layer and a gamification layer to the learning experience.

Case Studies of xAPI

There have been many xAPI implementation cases in the enterprise domain but few in the education

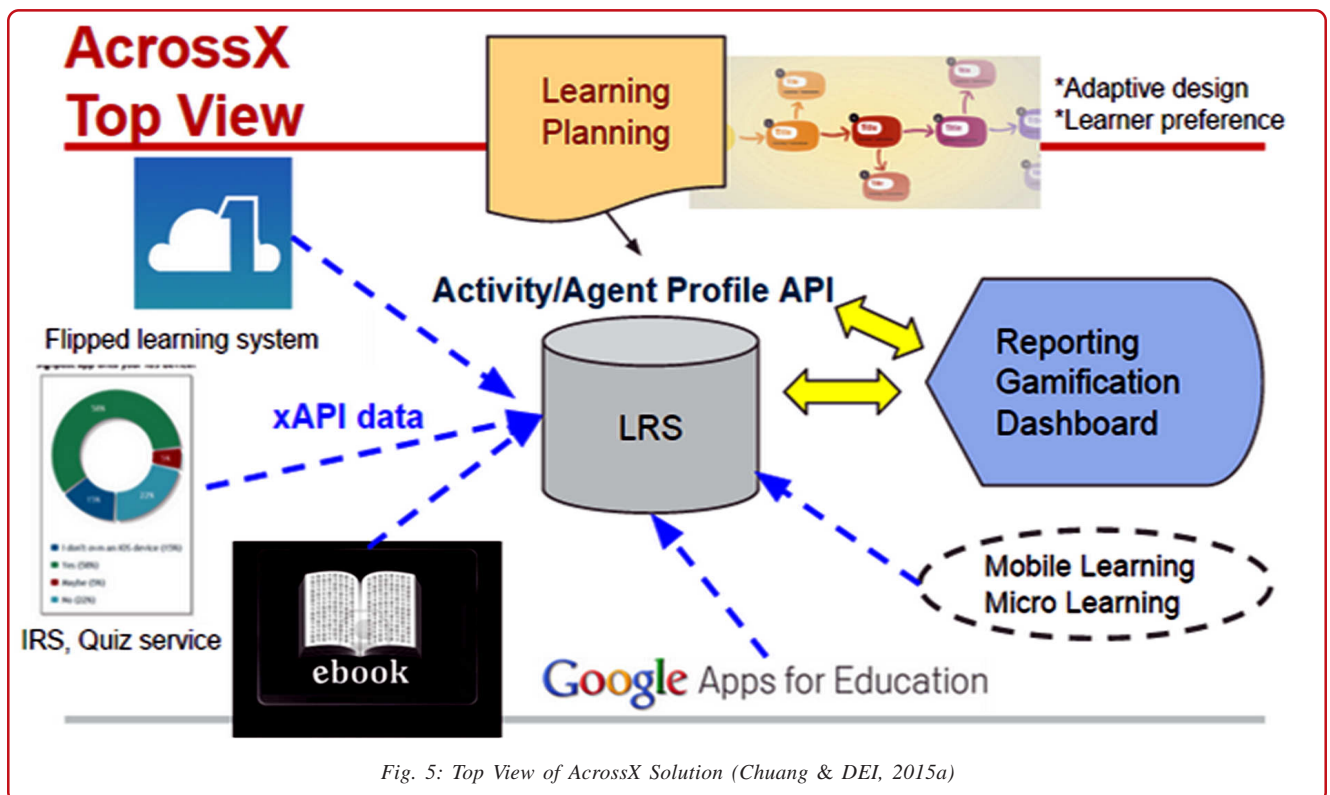


Fig. 5: Top View of AcrossX Solution (Chuang & DEI, 2015a)

A feedback widget gives real-time feedback to learners to nudge and encourage them. The project aims to support teachers and learners with integrated workflow and data flow for data-driven learning design and actions. Well-designed visualizations for xAPI data is crucial for efficient human perception. All xAPI data from interactions will become fuel to develop adaptive engine and recommender engine to build up an intelligent tutoring system for supporting independent learning. (Chuang & DEI, 2015a; Chuang & DEI, 2015b)

This project is being implemented in Taipei city, Taiwan. All teachers and students, about 350,000 in number, in Taipei city will be using this solution (later other areas will join); the public department is working towards building an ecosystem (from collaboration of public departments, schools, vendors, scholars, and developers) based on xAPI standard and open learning data as Open Data. New applications and data services can grow out of the ecosystem organically, or 3rd party tools can connect with it through API. (Fig.6)

- IEEE Actionable Data Book (ADB) is an open standard for ebooks based on the ePub3 standard and the latest learning standard xAPI for data-driven learning design. The IEEE ADB project grew out of a paper, presented at the 2011 IEEE Global Humanitarian Technology Conference by Richards & Barr (2011), about a broad framework for connected learning supporting inclusive education in developing countries. The requirements for the actionable data book are that it must be able to:

- ♦ Use camera and GPS data from a learner's mobile platform
- ♦ Use measurements from local lab equipment
- ♦ Exchange results of learning interactions with cloud-based LMSs, analytics engines, and other applications

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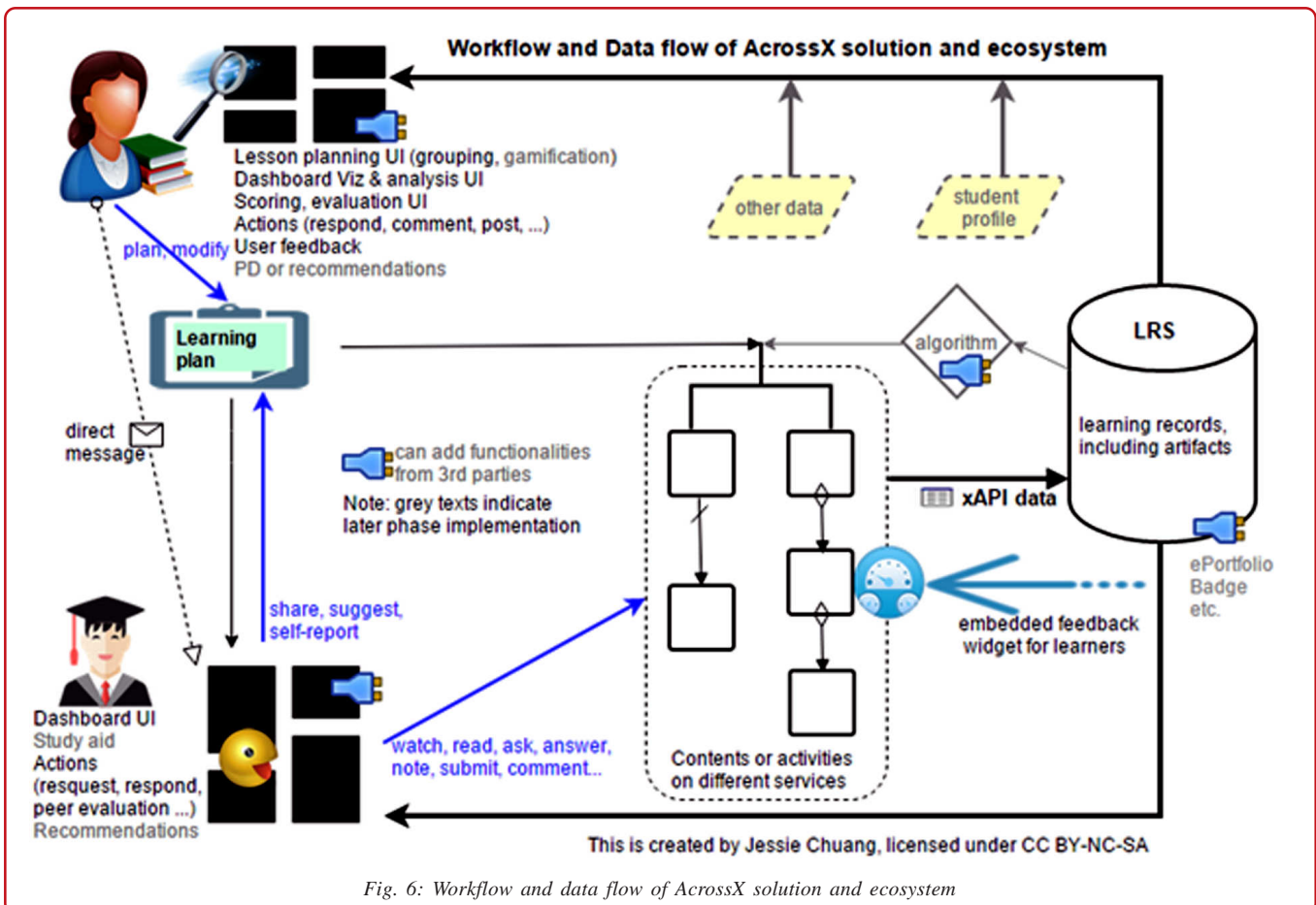


Fig. 6: Workflow and data flow of AcrossX solution and ecosystem

- ◆ Retrieve content from cloud-based sources (e.g. content repositories)
- ◆ Store and retrieve student history and preferences in the cloud

Although most of the technology used by the ADB project was developed for commercial purposes in the developed world, its application to learning was originally inspired by the desire to enable students in remote locations to collect field data and share their data and culture with other students in the world. The first case to which it would be applied is the construction of an enhanced, interactive guidebook for the new UNESCO World Heritage site in Bali (Lansing and Watson, 2012a; Lansing and Watson, 2012b; UNESCO, 2012). More possibilities are explored in the paper published by Arenas and Barr

(2013). The collaboration of IEEE ADB committee chair Costa, Chuang, Hu, Segall, & Polster (2015) have also demonstrated how to transform ordinary eBooks into “actionable databooks” with xAPI data-driven design.

- McKinsey Social Initiative (MSI) is an independent non-profit organization founded by McKinsey & Company that brings together expert problem-solvers to develop innovative approaches to complex social challenges. The CTO of MSI, Erlandson (2015) has proposed a program to track learning in practice for 15 years using xAPI. The aim is to solve youth unemployment, bridge the skills gap for 1 million learners in 5 countries across 3 continents, and hopefully build up scalable methodology.

Concluding Remarks

xAPI is a community-driven specification with contributors participating from around the world. The specification of xAPI has been released with a stable version for about two and half years up to now (Oct., 2015). In the past one year, its adoption has seen obvious rise because of long term considerations for learning and training purposes. ADL has developed open source resources, libraries, and wrappers for developers to use for their project purposes, check out ADL website

(ADLnet.gov) to find them. The best starting point to learn technical details of xAPI is from reading its specification (<https://github.com/adlnet/xAPI-Spec/blob/master/xAPI.md>).

The success of implementing xAPI comes from close collaboration of learning designers (educators), developers, and learning data analysts with support from management levels. It’s not a one-off project; the recommended strategy involves building up data and analytic loops to connect brains, and action loops to iterate forward continuously. For an interested organization, it can set aside an amount of resources each year to start from small scale, and expand step by step.

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Reviewer: Jason Haag's interest and background is educational technology and distributed learning systems. He spent eight years supporting the U.S. Navy's eLearning program in both engineering and management roles before joining the Advanced Distributed Learning (ADL) Initiative in 2009. Appointed as ADL's Mobile Learning Lead in 2012 and is a member of the ADL Technical Team, he provides support for SCORM, xAPI, and mobile learning (mLearning) research, including instructional design, performance support and best practices.

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Series Editor: Ramesh Sharma

Designer: Sabyasachi Panja



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Experience API (xAPI): Potential*

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Printed and published by Mr. R. Thyagarajan, Head (Administration and Finance), CEMCA, 7/8 Sarv Priya Vihar, New Delhi 110016, INDIA.

Website: <http://www.cemca.org.in>

