Experience API Overview

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Contents

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Purpose and Scope of the Document

In our day to day lives we have many learning experiences, both in the online and offline world, formally and informally and either individually or as part of a group. In moving towards a unified view of learning experiences it is evident that there are constraints. Where learning experiences are tracked, this is usually within the limited scope of SCORM in a Virtual Learning Environment (VLE) or Learning Management System (LMS), stored independently, or not at all.

1

Recently, there has been consistent and high level of feedback from Learnovate industry partners which has indicated that there is an emerging requirement to have a more holistic view of learners in learning and assessment environments. In moving towards a more powerful, standardised and universal approach to how we track learning experiences Experience API (xAPI) is introduced. xAPI is a specification for learning technology that allows us to track all kinds of learning activities, such as courses, mobile apps, social learning platform contributions and even offline learning experiences. Moreover, xAPI offers the ability to measure the learning experiences in a more quantifiable way than previous standards, for example SCORM.

This internal report explores xAPI from several angles. The report is the first step for the Learnovate team to start building expertise on xAPI. The overall Learnovate xAPI project has four goals associated with is.

1. Build a level of expertise on xAPI
2. Determine a 'best practice' approach to establish if xAPI should or could be adopted
3. Provide a detailed case study which outlines how xAPI can be appropriately implemented
4. Provide a guide which outlines how xAPI can be leveraged (a "How To" guide for Learnovate's partners)

These goals aim to ensure that if industry partners consider to adopt xAPI, Learnovate will be able to support them.
The report is divided into a number of sections:

- **Chapter 2:** Includes a timeline and definition of the key xAPI terms, outlines four examples of learning record stores and concludes with key issues surrounding the use of xAPI.
- **Chapter 3:** Focusses on the benefits and challenges of xAPI from a learning perspective.
- **Chapter 4:** Outlines nine, Learnovate focussed, fundamental xAPI questions and answers.
- **Chapter 5:** Presents the Learnovate case study outlining the learning record stores, a primary activity provider and associated statements. An outline of technical work is presented in addition to five recommendations for a secondary activity provider are proposed. The section includes the decisions behind the secondary activity provider with mock-ups presented associated considerations declared. The section concludes with implementation suggestions and mock-ups of the secondary activity provider interface.
- **Section Five:** Outlines the technical design for this xAPI project. The section concludes with the technical implementation.

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Introduction to xAPI

2.1 Introduction

This section is intended to introduce xAPI at a high level and will introduce a timeline and definition of the key terms. Statements, learning record stores and key issues conclude section two.

2

2.2 Timeline and Definition of Key Terms

2.2.1 Advanced Distributed Learning

The Advanced Distributed Learning (ADL) Initiative was a result of Presidential Executive Order 13111. Executive Order 13111 was signed on January 12, 1999 by President William J. Clinton, to ensure that the Department of Defense (DoD) and other federal employees take full advantage of technological advances in order to acquire the skills and learning needed to succeed in an ever-changing workplace (Advanced Distributed Learning, 2015).

2.2.2 SCORM

In response to the Executive Order 13111, the Sharable Content Object Reference Model (SCORM) was released in 2000. SCORM is described as a specification of the ADL which integrates a set of related technical standards, specifications, and guidelines designed to meet SCORM's high-level requirements—accessible, interoperable, durable, and reusable content and systems. SCORM had four main versions released from 2000 – 2009.

2.2.3 Rustici Software

In 2010, ADL issued Rustici Software with a research grant to propose an Experience API, an evolution of SCORM. Rustici Software conducted that research project under the code name "Project Tin Can" and submitted the "Tin Can API" as the result.

2.2.4 Project Tin Can

The Tin Can API is a brand new specification for learning technology that makes it possible to collect data about the wide range of experiences a person has (online and offline). This open source API captures data in a consistent format about a person or group's activities from many technologies. Very different systems are able to securely communicate by capturing and sharing this stream of activities using Tin Can's simple vocabulary.

2.3 Experience API (xAPI)

Project Tin Can became xAPI version 0.90 in 2012, with a more recent, and current version (1.0.1) released in 2013 (Advanced Distributed Learning, 2015).

xAPI tracks learning activities (for example formal, informal, online and offline) from disparate content and learning systems. This builds and improve on SCORM, examples include:

- No reliance on a web browser or a constant Internet connection.
- No requirement to know about activities ahead of time.
- Extending the tracking of individuals to group based learning experiences.
- Allowing the learning experience to be tracked.
- Learning experiences do not need to have originated in the LMS.

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- Richer data, for example mouse clicks, detailed test results.

A full specification is available from https://github.com/adlnet/xAPI-Spec/blob/master/xAPI.md

2.4 xAPI Overview

The xAPI uses REST (standard web architecture style developed by W3C) and JSON (human readable data interchange open standard). Via xAPI, any system can send xAPI statements, a record of the learning experience. As illustrated in figure 1, the statements from multiple systems are collectively stored, and are retrievable as statements in a learning record store (LRS).

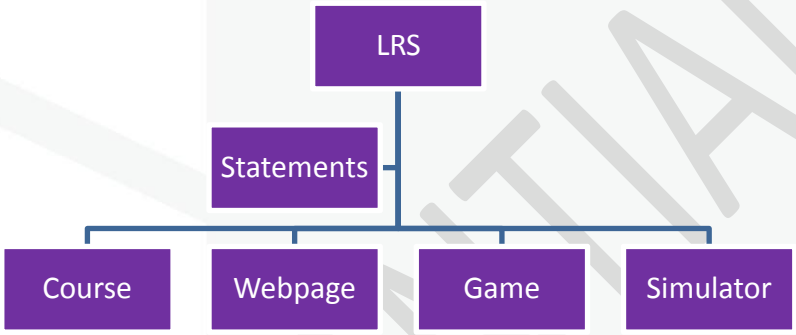

Figure 1: xAPI Basic Architecture

This remainder of this section outlines the fundamental components of xAPI, the statements and LRS in more detail.

2.4.1 xAPI Statements

Learning experiences are stored as statements. The three basic, but fundamental elements of statements are *actors, verbs and objects*, see figure 2. These elements are defined in the following subsections.

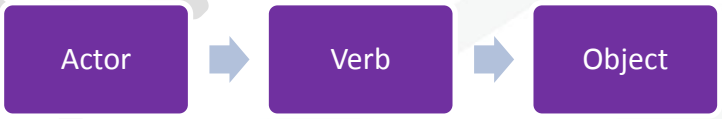

Figure 2: Elements of an xAPI statement

2.4.2 Actor

An *actor* can be an individual or a group with a unique ID. For example:

- Actor: Ben
- Unique ID: ben@tcd.ie

2.4.3 Verb

A *verb* describes the action performed during the learning experience. For example:

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- Answered
- Attempted
- Completed
- Shared
- Evaluated

2.4.4 Object

The *object* usually describes the actor's learning experience. For example:

- Business Seminar
- Chemistry 101 Lesson
- Virtual Simulation

2.4.5 Example Statements

The statements can range from basic to rich. Two examples of each are outlined:

- Ben achieved 'Level 6' in 'Factory Simulation' scoring 10 points
- Ben completed 'Manual Handling Level 3' on his iPhone, under the instruction of Jane

2.4.6 Learning Record Stores

The statements generated from learning experiences are stored in LRS via xAPI, LRS can be standalone which usually aggregate, report or visualise the data or can be part of an LMS (for example Moodle). The main function of an LRS is to validate and store incoming statements, then retrieve the data when queried (Advanced Distributed Learning, 2015). Developers can build their own LRS, which is considered a complex task, alternatively ADL have released an open source LRS for development purposes to store learning data collected with xAPI. The latest version is stable, but is only intended to support a small amount of users as a proof of concept (Advanced Distributed Learning, 2015).

2.5 Standalone Learning Record Stores

Four of the most prominent commercial and open source LRS are described below with the main features outlined and costs listed where applicable.

2.5.1 WaterShed LRS

Developed by Rustici Software, *Watershed LRS* (Rustici Software, 2015) is an **enterprise focussed** LRS which uses xAPI to understand what employees learn and do. *Watershed LRS* use a process called *Watershed Method,* which is a "considered study of learning activities and their impact on an organisation" to help better understand the things people in organisations do that make those people more (or less) effective. Although a commercial product, pricing has not been made available on the website.

The features of Watershed include:

- Creating experiments and viewing the results
- Analysing competencies
- Assessments
- Organisational hierarchy
- Population comparison
- Awarding badges for learning accomplishments

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- Tracking participation and training results
- Free-flowing data
- Observing the real-world performance of learners
- Learning path analysis

2.5.2 Wax LRS

Developed by Saltbox, Wax LRS (Saltbox, 2015) is an analysis platform tailored for **learning and development** professionals built on an enterprise tested LRS based on the xAPI. Wax LRS is a commercial product offering six different pricing structures ranging from *Pay-For-Usage (API Only)* to Enterprise ($9,500/per month with 10,000,000 statements per month). The features associated with Wax LRS include:

- Dashboards
- Timelines
- Score distributions
- Question analysis
- Influencer analysis

2.5.3 Learning Locker

Developed by HT2, *Learning Locker* is a conformant, open source LRS (HT2, 2015). *Learning Locker* is described as "the world's leading open source learning record store" as is **enterprise focussed.**

Learning Locker offers the option to install their free, open source solution onto servers or to avail of their *Cloud LRS* where *Learning Locker* is hosted by their cloud network for $199 per month with 500,000 supported statements. There is also the option of becoming an '*Enterprise Solutions Partner*' for global experts in the design and development of Learning Locker solutions, able to offer hosting, service and customisation at competitive prices.

Learning Locker features are outlined below with * representing features associated with the *Cloud LRS*:

- Open Source
- Commercial version available
- Export your data
- Customisable reporting
- Open source VIP support
- Private hosting*
- Open source support*
- Data strategy*
- Integrations / migration*
- Custom development*

2.5.4 ADL LRS

Developed by Advanced Distributed Learning, the ADL LRS is used to store learning data collected with the xAPI. It is a reference implementation of the system described in the xAPI specification. It is advised

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that this LRS is used for testing / development purposes only (Advanced Distributed Learning, 2015). The features of ADL LRS are outlined below:

- Original GitHub Examples
- Statement Viewer
- Statement validator
- ADL xAPI Tools
- Android App

2.6 Issues

2.6.1 Privacy

As previously highlighted, xAPI allows for the collection of large volumes of data which can make it difficult to draw the line between powerful reporting and what would be considered a breach of privacy (Rustici Software, 2015). It has been suggested that individual learners should have their own LRSs, or personal data lockers, in which they store all of their learning data for their own personal records (xAPI Test Environment, 2015) to help with this data privacy issue.

xAPI provides a blue-print for federated ecosystems in which data about learning events is shared with a Learning Record Store. One part of this blue-print prescribes the use of two standards to address security and privacy needs in an xAPI based ecosystem. These two standards are OAuth and "Basic HTTP Authentication". Every organisation which implements an xAPI ecosystem is advised by the xAPI standard to implement one of these two security standards to secure the learning data.

1. "Basic HTTP Authentication" is based on the same standards which are used in the wider IT area since the inception of the World Wide Web in the 90s, and presents a baseline in terms of security. It allows controlling the access to data, however it does not allow for more advance capabilities such as authorisation of 3rd parties to access data on behalf of a user, or the revocation of authorisation for 3rd parties. Using "Basic HTTP Authentication" is suitable for ecosystems without external data providers.
2. In contrast, OAuth goes beyond classical authentication mechanisms of the World Wide Web. It allows a user to authorise external 3rd party providers to access his data until a point in time when the user decides to revoke this authorisation.

In summary, xAPI provides an integrated approach to secure the data of an xAPI based ecosystem. However, this will also require adding support for the relevant standards to all components of the xAPI ecosystem.

2.6.2 Volume of Data

The volume of data being written to LRS has the capacity, even in a small ecosystem, to be large. For example xAPI generate 60,000 statements by just a handful of individuals (Betts, 2014). As a result in larger implementations of xAPI, the resulting large volumes of data means that it is becoming harder for those managing learning programmes to recognise the meaning behind the data and draw conclusions (Brightwave, 2015).

In order to integrate data from internal and external sources into an ecosystem based on xAPI, the data from these sources has to be converted to xAPI statements. These xAPI statements should use the vocabulary and the syntax as defined by the organisation maintaining the xAPI ecosystem and

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the Learning Record Store (LRS) at the centre of the ecosystem. However, it can be challenging to formulate a vocabulary that fits not only the requirements and specifications of current data providers, but also those of future data providers.

One of the main points when marketing xAPI is the idea of "life-long learning". xAPI aims to support the goal of life-long learning by aggregating learning events and experiences of an individual over a very long time span, ideal over his/her whole life.

While this goal is within reach of the technical capabilities of xAPI, it is only practically achievable if the ecosystem in which the learning data is collected is carefully maintained. In addition, growth and change management as described in this section are an absolute requirement for any ecosystem in which life-long learning is encouraged. Without making growth and change management a first-class priority it will be almost impossible to relate and compare learning events collected at different points in time.

Imagine a learning event related to successfully completing a first aid course in 2015, and a similar event for successfully completing a first aid course in 2025. Even if both statements use the same verb and the same syntax, how will an analytics component be able to deduce that both events are about first aid, without some sort of subject categorisation system? This subject identification system would need to guarantee that the same subject identifier is used for the concept of "first aid" in 2015 and 2025.

To further complicate the matter, if such a subject identifier is agreed upon, then it might not be used if the first aid course in 2015 was organised by a different first aid training organisation as the one in 2025. There might be no incentive for an organisation to check for existing and reusable subject identifiers for use in xAPI statements generated by that organisation. In such a case, no comparison of learning events would be possible without having a human expert add the connection between the two first aid courses to the LRS.

In summary, one of the main goals of xAPI is to enable and facilitate ecosystems with many data providers and fast growth. However, the management the growth and change of an ecosystem has to be managed by an organisation, as this goes beyond the scope of the xAPI standard as such.

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xAPI: The Learning Perspective

3.1 Introduction

Having provided a mostly technical overview of xAPI in section one, it is important to note and discuss the benefits and challenges of xAPI from a learning perspective.

3

3.2 xAPI Learning Perspective: Benefits

From a learning perspective, there are **three main reasons** for considering implementing xAPI.

- **Benefit 1:** xAPI is **learner-centric**. The original ADL Initiative was taken to ensure that federal employees take full advantage of technological advances in order to *"acquire the skills and learning needed to succeed in an ever-changing workplace"* (Advanced Distributed Learning, 2015). The learner is at the centre of all experiences and activities reported; *not* a course or the used technology (Delano, et al., 2013). (Marray, et al., 2013) even take it a step further. They state that *"people need ownership over their learning experiences and the data that reflects what they have learned and what they have achieved"*.

- **Benefit 2:** **xAPI is able to bridge between the virtual and the real world**, between digital and physical experiences and it supports capturing and sharing of hybrid learning experiences (Megliola, et al., 2014). xAPI enables *"real-time collection and analysis of learning experiences conducted in different contexts, with the aim of providing better interoperability between the different types of systems and devices"*. In today's world, there are various, disparate learning experiences available to individuals. The experiences can be formal, such as e-Learning, face-to-face courses and coaching sessions or informal, such as peer learning, watching a video, collaborative projects, and so forth. A remote system with knowledge of the learner's activity can send a statement to an LRS with details of what the learner did (Brownlie, 2014), (Marray, et al., 2013) argue that "*Learning experiences can be identified and designed to provide activities that could provide evidence of competence or even mastery towards a given competency"*. In addition they state that xAPI has the power to track activities in the context of the (learning) task that provide evidence of competency.

- **Benefit 3:** xAPI allows for **flexible reporting and analysis**. xAPI makes it possible to report granularity and detail.

Although xAPI has major benefits to track and analyse learning experience, there are also several challenges from a learning perspective, which will be explored in the next section.

3.3 xAPI Learning Perspective: Challenges

Using the xAPI allows previously uncollected learning-related data from disparate learning experiences to become immediate and accessible. However, in order to enable objective measurement of learning as in behaviour change or business impact, we require consistent data types that can collate all learning experiences (Brownlie, 2014), and ideally show how they are related or correlated. However, this is where we arrive at the first challenge.

- **Challenge 1:** xAPI is an observational tool that tracks human interaction but it is not able to identify if learning actually took place.

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Although it is important to acknowledge that xAPI does not *aim* to measure learning impact, it is a **design challenge** because it is critical in a learner-centric approach, as xAPI intends to be, to be able to identify *what* people learn, *how* they learn and what the impact is on their *performance*. It is important to note that this challenge relates to measuring learning impact and therefore refers to assessment. In other words, assessment focusses on the learning achievements of the individual. Many case studies focus on groups (e.g. Torrance Learning's Museum Project). Within this type of xAPI implementations, the focus is not on assessment but on evaluation. For example, xAPI is used to analyse how groups of learners behave within a learning experience or to identify if a learning intervention is successful. It is important to be aware if you are looking for insights in an individual's learning achievements or if you want to be able to analyse groups.

- **Challenge 2**: When implementing xAPI it is critical to carefully distinguish between assessment and evaluation.

  - **Assessment** can be defined as *the systematic collection of data to monitor if the learner has achieved the intended learning objectives.* Assessments focusses on what the learner has learned, the way they learned and their approach to learning before, during, or after the learning intervention. There are many different assessment methodologies available such as online tests, essays, observations, simulations, and so forth.

  - **Evaluation** can be defined as a *judgment about whether the learning intervention has met its intended learning outcomes*. Evaluations tend to be retrospective analyses of data. For example, correlating training with performance data or learner feedback surveys. (Benedek, 2013) states that neither xAPI nor TLA *"will be able to function as a specification for planning learning scenarios"*. According to the author both standards rather serve on the fly personal learning plans. However, Benedek continues that xAPI might be able to find better ways to achieve learning goals by making data accessible about actual learning practices. Benedek suggests that the types of data collected my influence what patterns we find and what meaningful actions we can take based on the data. In other words, Benedek refers to evaluation, without specifying it as such.

  Some would even argue that, when you gather sufficient data, you can identify valuable or more effective learning experiences. However, it is not that easy. (Delano, et al., 2013) explain that analytics are usually more high level views of data while learning *analysis* encompasses much more. In addition, (Fox, 2015) argues that nearly all data and analysis used will be correlational by nature. Correlational analyses can be good for prediction, however, they are not always able to identify how to change or influence learning or performance. Also, as we all know, correlation does not imply causation. (Brownlie, 2014), provides an example in which an organisation attempts to correlate xAPI parameters with actual business results. This analysis might produce findings like "Sales people with the highest revenue in Q2 took training classes X, Y and Z". There could be many reasons why sales people with the highest revenue in Q2 took these training classes that have nothing to do with the effectiveness of the training. Perhaps *all* sales people took the same training classes as part of mandatory training. If that is the case, the worst performing sales people also took training classes X, Y and Z.

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- **Challenge 3**: *"A whole new level of statistical experience is required to initially design for and make sense of learning analytics and there is great potential for misreading the available data"* (Brownlie, 2014).

  (Ferguson, 2013) argues that, as learning analytics emerge from the wide fields of analytics and data mining, its researchers need to collaborate with learning specialists. That way, there is a potential for a two-way process, with learning analytics forming the basis for good learning design and effective pedagogy.

  So although xAPI allows for flexible reporting and analysis (benefit 3), it needs a certain level of expertise to be able to do this effectively.

- **Challenge 3a:** Learning Designers and Data Scientists both have a skills shortage (Brownlie, 2014).

  Learning Designers are uncertain of how to design for the data that is being collected. Data Scientists have insufficient knowledge on how to evaluate learning impact. They need to collaborate and learn from each other in order to be able to implement an effective xAPI solution. Another sub challenge with regard to design for and interpret data is the **focus**. (Brownlie, 2014) carefully compares the xAPI structure with SCORM and alternative tracking methods, such as Open Badges, web page logs, Google analytics, HTTP cookies and mouse and eye tracking. From this comparative analysis, two fundamental challenges arise when applying the general tracking methods to learning experiences for individual users. First, in order to be able to attach particular meaning or context to the tracked variables, significant retrospective analysis is required. Second, all the tracking methods have been developed to evaluate **sites**, not learner-centric experiences. xAPI is the preferred method to track and analyse learning experiences. However, even when using xAPI instead of general tracking methods, the risk is still that the tracking of the learning experiences will be site-centric and technology led. It is critical to understand your users and their focus or goal rather than relentlessly tracking as many activities as possible (Downes, et al., 2013).

- **Challenge 3b** – Ensure that the focus is on learner-centric data, not site-centric data.
  One way of checking the focus of the data is to ask the following question. If you were to aggregate the data in a graph, would it tell you about:

  - How many users engage with a site or tool? If so, your focus is on *site-centric analytics*.
  - How a single user engages with different sites or tools? If so, your focus *might be* on *learner-centric analytics*. The next question to check your focus would be:
  - Can the engagement that you are tracking be associated with learning experiences and if so, how?

Last but not least, one of the major dangers is that the **tracking will be technology-led**. It is critical to understand your users and their focus on goal rather than relentlessly tracking as many activities as possible (Downes, et al., 2013).

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Fundamental xAPI Questions

4.1 Introduction

Having introduced xAPI from a technical and learning design perspective this section aims to explore the strengths and weaknesses of xAPI with nine Learnovate specific questions which include:

4

1. How mature is xAPI?
2. What implementations are out there?
3. Are there any implementations that have been successful?
4. Does xAPI have a role to play in defining learner profiles?
5. Can xAPI support unified user modelling?
6. Is it an essential part of the glue that would enable unified view of learner progress across multiple platforms/applications?
7. Are there differences between K12/Corporate?
8. Can we implement xAPI for any of our existing/past projects?
9. What are the implications of xAPI for Data Privacy, The future of the LMS/VLE and the Design of EdTech APIs more widely?

4.2 How mature is xAPI?

xAPI is currently not considered mature. It is still unstable and is subject to frequent changes.

4.3 What Implementations are out there?

There are a number of implementation of xAPI – four examples are outlined.

- **CM-Group:** CM Group (CM-Group, 2015) use xAPI in range of e-learning and mobile learning products (named Luminosity) to track all content access to drive analytics which provides valuable insights for their customers. This approach determines which learning content and strategies are popular and drives all reports and a gamification element. An example of how Microsoft are using xAPI within CM-Group is outlined below:
  - xAPI tracks all engagement within a mobile app specifically designed for new Microsoft HR managers worldwide to receive management education and training, enabling social discussion and interaction. The app is largely based on a gamification concept with new managers aiming to achieve points from assessment of their knowledge within topics relating to their new role, shown in an in-app leader board. It is claimed that xAPI is reducing training costs and allowing quicker time to productivity for new mangers which is increasing engagement levels and the motivation of the new HR managers.

- **TES (Training Evidence Systems):** TES (TES, 2015) help clients capture on the job training and performance data with the end goal aiming to measure the impact of training and ultimately help make better training investments. A number of apps are used to capture training data which include work place assessments, attendance, scheduling and on the job coaching. xAPI is specifically used to allow clients to share the data collected from the TES products with their other business systems.

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- **Brightwave:** Brightwave (Brightwave, 2015) use xAPI to capture informal learning experiences within their tessello e-learning product. A bookmarklet is primarily used to allow users to track and store their informal learning experiences. Users have the ability to manage these learning experiences and have the option of sharing them with the tessello community. An example of how two companies are using xAPI within Brightwave is outlined below:
  - **Unison:** Capture learning experiences across the organisation using xAPI, share best practice and social learning which helps coordinate 'on the ground' actions.
  - **3M:** Teach product knowledge training across Europe, xAPI allows customers who use 3M products to feedback and to engage within the social system.

- **Torrance Learning:** TorranceLearning (TorranceLearning, 2015) use xAPI enabled RFID tags in a museum setting to track children's movements with exhibits and to track quiz results associated with each exhibit. This information can be shared in reports with the children, the teachers and museum staff. xAPI helps to obtain interesting data which shapes the learning experiences within the museum.

4.4 Are there any Implementations that have been successful? In terms of: Experience Tracking, Competency Infrastructure, Content Brokering, Learner Profiles?

In determining if the four aforementioned components are successful (from a technical perspective), it is important to note that the components collectively form part of the Training and Learning Architecture, as defined by ADL, see figure 3. The section continues by introducing the definition of each of the components with a collective statement on successful implementations.

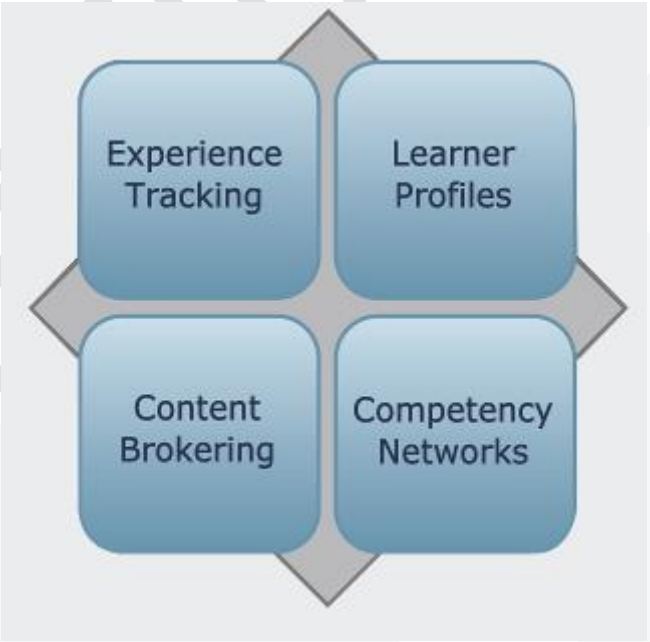

Figure 3: Training and Learning Architecture

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4.4.1 Experience Tracking

According to ADL experience tracking is defined as "specifications and software that can be used to track learner data based on interactions with learning experiences. Learning experiences can derive from many contexts, including formal courses, simulations, informal learning with websites and videos, games, and social media interactions. A critical characteristic of this component is making that data available for use in other authorized systems after it has been stored." (Advanced Distributed Learning, 2015)

4.4.2 Competency Infrastructure

ADL define competency infrastructure as "specifications and software that can enable learning objectives and competency definitions to be used by content and systems to establish proper relationships. These relationships will map content/courses to objectives/competencies based on the established definitions." (Advanced Distributed Learning, 2015)

4.4.3 Content Brokering

According to ADL content brokering is defined as *"specifications and software to manage content to support just-in-time learning and enable selection of the next logical activity. Smart components and machine-readable content will source the next learning experience from shared content, appropriate for the learner's context and device."* (Advanced Distributed Learning, 2015)

4.4.4 Learner Profiles

ADL define learner profiles as *"specifications and software used to provide access to data about learners such as learner preferences and course history. The information found in the profile can be used to tailor a learning experience to an individual by taking into account the learners specific style and experience within a subject. The profile can develop with data from many sources, including experience tracking and learner-entered information."* (Advanced Distributed Learning, 2015)

Having introduced each of the four contributing components of the Training and Learning Architecture it can be concluded that the implementations of xAPI, outlined in 8.2 contribute, to some degree, to all four components. Though it should be stated that it is difficult to determine the exact success of the implementations as the case studies provided are not particularly detailed, in addition there are not independent and potentially biased as they are usually provided by the service provider.

4.5 Does xAPI have a role to play in defining learner profiles?

The strength of xAPI is aggregating learning activities (for example formal, informal, online and offline) from disparate content and learning systems. The learner profile is currently considered as something which is separate from the learning activities recorded by xAPI. While ADLnet lists Learner Profiles as one of the components of the Training and Learning Architecture, the xAPI standard by itself only enables "Experience Tracking", which does not play a role in defining learner profiles.

4.6 Can xAPI Support Unified User Modelling?

The question of supporting unified user modelling is dependent on the goal for which the user model is meant to be used. For an e-Learning use case, the goal most likely will be to support the learner by e.g. personalising content for the learner (as for "content brokering"). The data collected by xAPI can be used towards this goal, however the learner profile is an additional required input. This suggests

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that unified user modelling is an indirect goal, and the impact of xAPI on this goal has to be seen from practical experience, e.g. by implementing a prototype application.

4.7 Is it an Essential Part Of The Glue That Would Enable Unified View Of Learner Progress Across Multiple Platforms/Applications?

In order to enable a unified view of learner progress across different applications, data from those applications needs to be aggregated. This is a fundamental technical requirement which is independent from other, conceptually more abstract goals. As an interoperability standard, xAPI provides a common framework for enabling this aggregation of data. Any other functionality, which might be required for e-Learning, such as analytics to detect learner progress in the broadest sense, is not specified by xAPI and has to be added to each respective xAPI-based ecosystem. However, this provides an opportunity for Learnovate to add value to xAPI-based ecosystems.

4.8 Are There Differences Between K12/Corporate?

The main difference between K12 and corporate environments for xAPI is arguably the data privacy / protection concerns. These data privacy / protection issues do vary from country to country and are notoriously stricter when dealing with children and young adults. Data ownership remains the key issue and one which has not been addressed by xAPI.

4.9 Can We Implement xAPI For Any of Our Existing/Past Projects?

Theoretically xAPI can be used for all existing and past projects. However, it is critical to identify *why* we are implementing it and why we are tracking the data that we are.

4.10 What Are the Implications of xAPI For: Data Privacy/Protection?

Data privacy / protection is an important issue for xAPI, this is particularly prevalent for student data, as previously mentioned. Because the API is open source “an educational organisation can collect and store the data in-house and not through a third party vendor, which takes care of some of the privacy concerns”, but not all (edSurge, 2015). It has been suggested that a number of outstanding privacy issues associated with xAPI “can be better addressed by allowing the person who is being tracked to collect their data and share it with whom they choose, in a personal data locker, rather than the tool or organisation collecting all of the data about a person by default” (Fox, 2015). Though it should be noted that these two proposed solutions do not fully address this contentious issue.

4.11 What Are the Implications Of xAPI For: The Future of the LMS/VLE?

LMS/VLEs still play an important role for formal learning for both education and business. As learning becomes more informal, social and mobile it is clear that LMS/VLEs currently cannot support such learning experiences. Resultantly, LMS/VLEs will need to diversify to accommodate both formal and informal learning experiences. xAPI can play a role in such diversion through the integration of a LRS which can track and record both learning experiences which can be collectively reported in an LMS/VLEs. In summary and in terms of xAPI replacing LMS/VLEs, xAPI is not (1) mature enough, (2) being used to a large extent, or (3) has provided enough evidence were can be considered as a replacement to LMS/VLEs (TinCanAPI, 2015).

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4.12 What Are the Implications Of xAPI For: The Design of EdTech APIs More Widely

The design of APIs in the EdTech area is expected to follow the leaders in the IT area in general. These leaders are setting general trends regarding e.g. architectural questions, interoperability of data and the security model used to access and transport data. It can be expected the EdTech area will follow the leaders in this area, by adapting existing standards and architecture to the needs of their stakeholders. xAPI can be seen as the first outcome of this, as it closely mirrors current ecosystems for sharing of user profile data in social media. Ecosystems which are very similar to the ones proposed by xAPI are used daily by millions of users through Facebook, Twitter and Instagram. In turn, xAPI adapted the general architectural framework and the specific technical standards used in these ecosystems to the general area of EdTech. If xAPI as a standard turns out to be a failure then it might be replaced by a standard with a very similar architectural framework.

In Summary, xAPI can be expected to have a strong impact on EdTech APIs, as it picks up from the leaders in IT in general. Any future APIs in the EdTech area can be expected to have one or more areas of overlap with xAPI in its current form.

Case Study

5

5.1 Introduction

In order to evaluate xAPI in a practical way within Learnovate, an implementation of a LRS is required. In this section the installation experience is documented for two open source implementations, Learning Locker and ADL LRS, both of which were briefly described in section one. These implementations allow Learnovate to evaluate xAPI without any commitment to a specific vendor or commercial contract. The disadvantage associated with this approach means that the support available for open source LRS is very limited. The second part of this section outlines the chosen primary activity provider.

5.2 Learning Locker LRS

The open source version of the Learning Locker LRS is implemented in PHP using the Laraval web application framework. It provides a graphical user interface for managing separate LRS within the same installation. Each individual LRS can have different users with different roles which limit the statements the user can read or write. For external creation of statements, the Learning Locker LRS does support basic HTTP authentication. OAuth support is mentioned in the documentation but it is not clearly documented how to turn it on.

The installation and setup of Learning Locker took approximately **3 days**. No self-contained description of the installation process is available from Learning Locker, however Learnovate have documented how to install the LRS. In addition, almost no documentation for end-users and developers is available, and there is no dedicated forum for support.

5.3 ADL LRS

ADL are the main organisation behind the xAPI standard. To support adoption of the xAPI standard, ADL provide an open source reference implementation of an LRS, which is available to use free of charge. The reference implementation is based on Python and the Django web application framework. It provides a graphical user interface to managing users and statements. When downloading the software a disclaimer is displayed in a very clear way. The disclaimer explains that the reference

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implementation **is not meant to be used for production systems and that it is not scalable regarding the number of users.**

The ADL LRS reference implementation supports both basic HTTP authentication and OAuth, and it is clearly documented how to turn OAuth on and off. As OAuth is turned on by default, this suggests that ADL is confident about the maturity of their OAuth support.

Installation and setup took roughly **2 days**. There is a self-contained description of the installation available, however it lacked any instructions on managing different Python or Django versions. There is very little documentation for end-users, however many aspects of the Learning Locker LRS which are not documented, are documented for the ADL reference implementation. For instance, there is detailed documentation on how to use different versions of OAuth with the LRS.

5.4 Learning Record Store Summary

It is evident from the implementation of both Learning Locker and ADL that there are a number of issues. The common issue is the lack of instructions and descriptions of the installation process. It is determined that an installation of *Learning Locker's* LRS onto local servers would be the best option for the following reasons:

- Open source
- Stable release
- In house technical knowledge to install and manage
- In house learning design support
- No restrictions on the number of statements
- No monthly hosting costs
- Can be adapted for educational purposes.
- High performance query API which extends the query API as described in the xAPI specification.

5.5 Activity Providers: SkillTrack! + Activity Provider Prototype

In order to provide a real-world xAPI experience, we realised we needed at least two activity providers. First, in leveraging a Learnovate project it was anticipated that SkillTrack! project, outlined below would be the most appropriate.

> *SkillTrack! is a learning application for a tablet device that brings together several technologies and is designed to make learning more interesting and effective for students by supporting the practice, development and self-review of 21st Century/Key Skills (collaboration, communication, creativity, information management, self-management). Specifically, the project is interested in how the Key Skills are identified, defined, exemplified and evaluated by students.*

The second activity provider, the SkillTrack! Prototype demonstrator has been explicitly designed for the xAPI project in order to demonstrate:

1. How to integrate the Learning Locker LRS into the SkillTrack! architecture
2. How to integrate an external activity provider into the SkillTrack! architecture

This section provides information on extracting xAPI Statements from existing SkillTrack! user actions, the section is broken down into three stages outlined below:

- **Stage One:** Choosing Verbs/Activities

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- **Stage Two:** Standardisation
- **Stage Three:** SkillTrack! User Action Mapping

5.5.1 Choosing Verbs/Activities

It is evident that there needs to be a balance between how specific a verb can be and how specific an activity can be. You can have generic verbs and detailed activities or more specific verbs and less detailed activities. If you have generic verbs, the burden of detail falls on the activity and vice versa. In SkillTrack! there are have various interactions between a student and the user interface of the table app. For example, there are different ways to model a statement:

- Student interacted with ranking activity
- Student interacted with free text activity

The student is doing two very different things, but the verbs are the same. In this case the ranking activity and free text activities would need to be given quite detailed definitions. But if we use more specific verb we can provide a more nuanced model. For example:

- Student ranked element
- Student submitted free text

5.5.2 Standardisation

Having identified the issues associated with choosing verbs and activities, the challenge is to make statements as standard as possible and still retain meaning specific to an activity provider.

A number of ways xAPI data model does not fit our model.

- In xAPI you can define **interaction activities** that models where an actor has some interaction with some component. An example of this would be a question in a multiple choice text. The activity definition defines the list of possible answers. The definition also includes the correct answer. An interaction activity could include ranking, selecting and rating. This is more suited for an activity that produces a right or wrong answer. Interaction activities would seem to closely mirror the interactions that are contained in the user experience in SkillTrack!, for example, a selection. However, it is unclear how a statement can be linked to an activity definition. To analyse all choice interaction activities, for example, **a component outside the LRS would have to do the work.**

- The xAPI schema allows for the use of **extensions**. Extensions allow information that doesn't directly link an experience to the xAPI schema to be recorded. An object, context and result can all include extensions. The key thing about using extensions is to use them sparely. A statement that consists solely of extensions loses the benefits that are to be gained by using xAPI. **Using extensions, the complex user interactions such as ranking, free text, selections can all be modelled.**

Over time, this can provide a fuller picture of user learning experiences.

5.5.3 User Action Mapping

The basic format of xAPI statements is – **actor verb object** – or, someone does something. The first challenge when generating xAPI statements is to choose the correct verb and object to describe an experience.

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SkillTrack! actions can be broken down into 3 stages:

- **Stage 1:** Actions around the mechanics of the app, for example student starts phase 1 or student completes phase 1. See table 1 for further examples.
- **Stage 2:** Actions around open badge applications, for example student submits badge application or teacher approved badge application. See table 2 for further examples.
- **Stage 3:** Actions around what the students actually do in the app, or learning actions, for example student ranks elements or student submits free text. Things where we can apply more complex and potentially interesting analytics. See table 3 for further examples.

Table 1: SkillTrack! App Mechanics Actions

Action	Actor	Verb	Object	Context
Student starts a phase	student	started	phase	skill, phase
Student completes a benchmarking phase	student	completed	benchmarking phase	skill, phase
Student starts an exemplar phase	student	started	exemplar phase	skill, phase
Student completes a phase	student	completed	phase	skill, phase

Table 2: SkillTrack! Open Badge Actions

Action	Actor	Verb	Object	Context
Student uploads an image that exemplified an experience in a skill	student	uploads	exemplar	skill, phase
Student has reached the end of a phase and submits a badge application	student	submitted	open badge application	skill, phase
Teacher approves a badge application made by a student	teacher	approved	open badge application	skill, phase

Table 3: SkillTrack! Learning Actions

Action	Actor	Verb	Object	Context
Student watches an instructional video	student	watched	video	skill, phase, questionType
Student views an information screen in a phase	student	viewed	info screen	skill, phase, questionType, question, part
Student tags a skill when they feel they have experienced that skill	student	tagged	skill	skill, phase
Student submits free text in response to question in a phase	student	submitted	free text	skill, element, outcome, phase, questionType, question, part
Student rates themselves in a skill/element/confidence/ability	student	rated	skill/element/outcome/confidence/ability	skill, element, phase, questionType
Student selects an element/ outcome/action	student	selected	element/outcome/ actions	skill, element, outcome, phase, questionType, question, part

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Student associates words or phrases with an element/ outcome	student	associated	element/outcome	skill, element, outcome, phase, questionType, question, part
Student ranks skill/element/ outcome	student	ranked	skill/element/ outcome	skill, element, phase, questionType, question, part

As previously highlighted there needs to be a balance between how specific a verb can be and how specific an activity can be. The challenge is to make statements as standard as possible and still retain meaning specific to an activity provider. Interaction activities and extensions can provide a fuller picture of user learning experiences

5.6 Secondary Activity Provider: Suggestions

In order to be able to provide a 'real xAPI experience', we need to find an effective way to collect data from not only SkillTrack! but also another activity provider that will provide additional and meaningful data and to increase the value of the case study. Furthermore, the current xAPI project only runs until the end of June 2015, hence the need to select an activity provider that will be relatively easy to design and develop. This approach aims to firstly demonstrate how an LRS aggregates data from various systems and secondly, how these data then need to be analysed in a meaningful way.

The pedagogical team listed various possible extensions for SkillTrack! These extensions all focus on increasing the value of SkillTrack! for both the student and the teacher. The extensions are all based on the educative relationship; that is all the relationships that exist in the classroom among student-teacher-knowledge.

- **Option 1:** Student to self
- **Option 2:** Student to student
- **Option 3:** Student to teacher
- **Option 4:** Student to knowledge
- **Option 5:** Teacher to self
- **Option 5:** Teacher to teacher
- **Option 7:** Teacher to student
- **Option 8:** Teacher to knowledge

Based on these options, five recommendation are proposed below.

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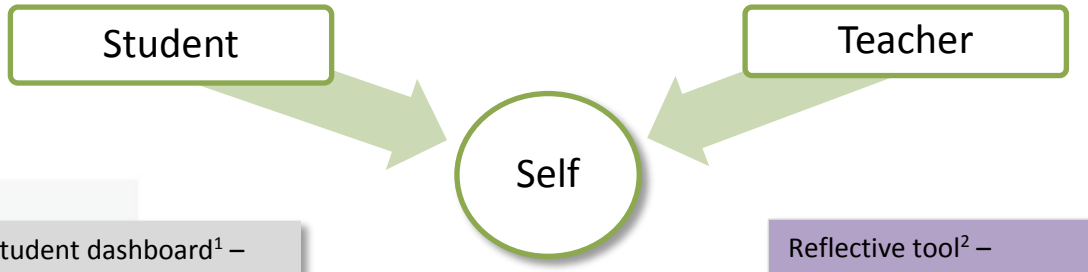
5.6.1 Recommendation 1: Student/Teacher to Self



Student dashboard[1] –

Sense of practice

[1]ST because it makes most sense to aggregate and visualise the data for the student within ST itself.

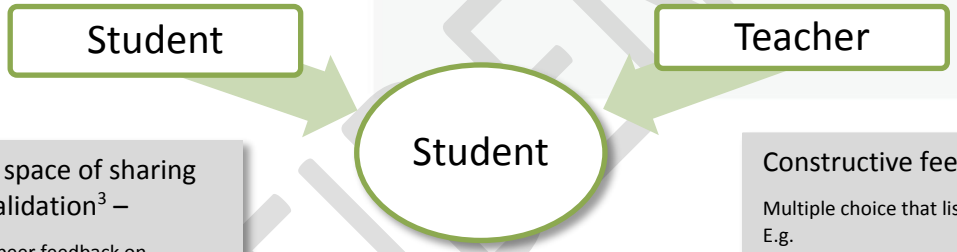
Reflective tool[2] –

Tag skills as covered in lesson plan. Do they focus relatively often on one skill? And how does student data relate to that?

Most feasible within time frame?

[2]This could be a separate tagging tool. Would need to be easy to plug whatever the teacher uses for creating their lesson plan?

5.6.2 Recommendation 2: Student/Teacher to Student



Social space of sharing and validation[3] –

Peer to peer feedback on exemplars and explanations

[3]ST because exemplars are uploaded in ST. This type of activity does need to happen outside of the classroom.

Constructive feedback[4]

Multiple choice that lists options. E.g.

Good exemplar of skill and well explained
Good exemplar of skill; explanation lacks clarity

[4]ST because exemplars are uploaded in ST. Makes most sense to populate the feedback where the exemplar is located.

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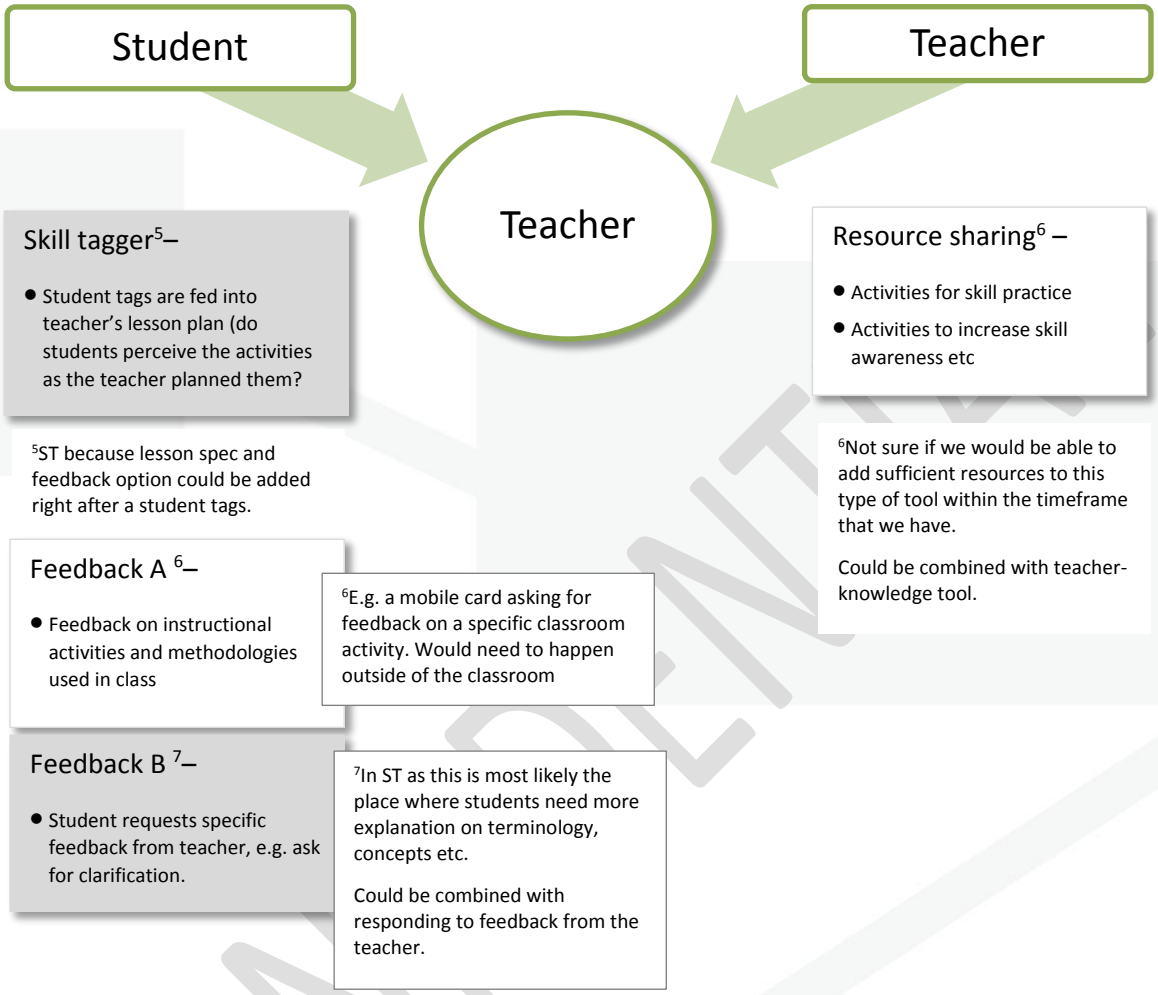
5.6.3 Recommendation 3: Student/Teacher to Teacher



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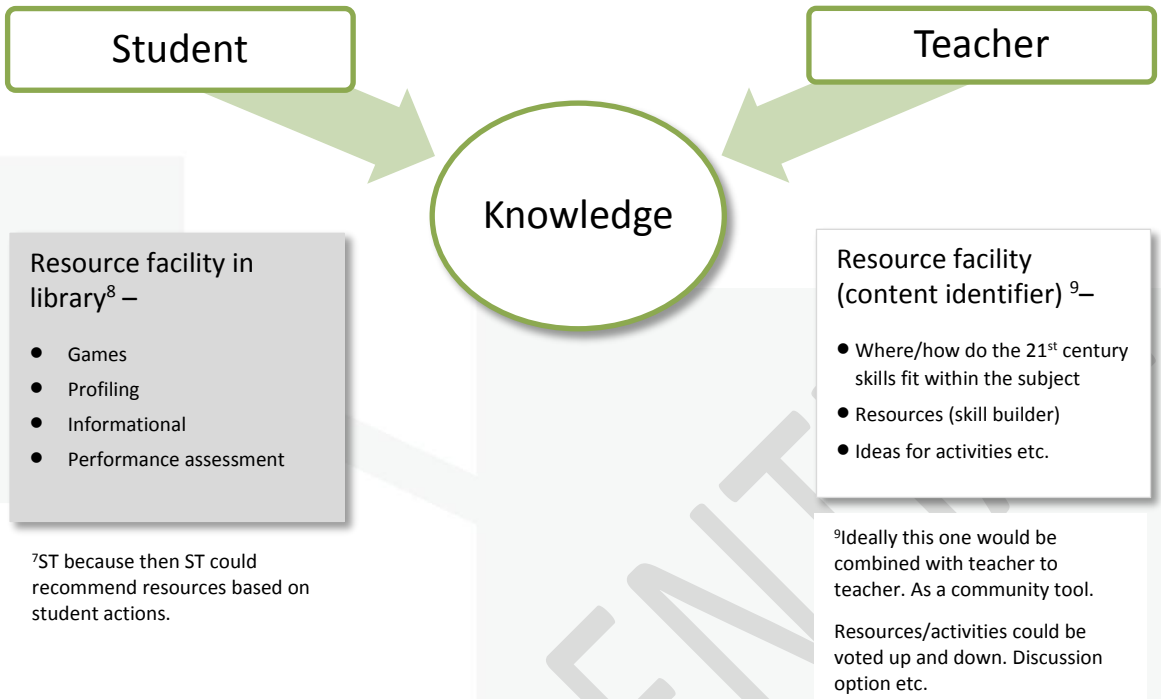
5.6.3.1 *Recommendation 4: Student/Teacher to Knowledge*

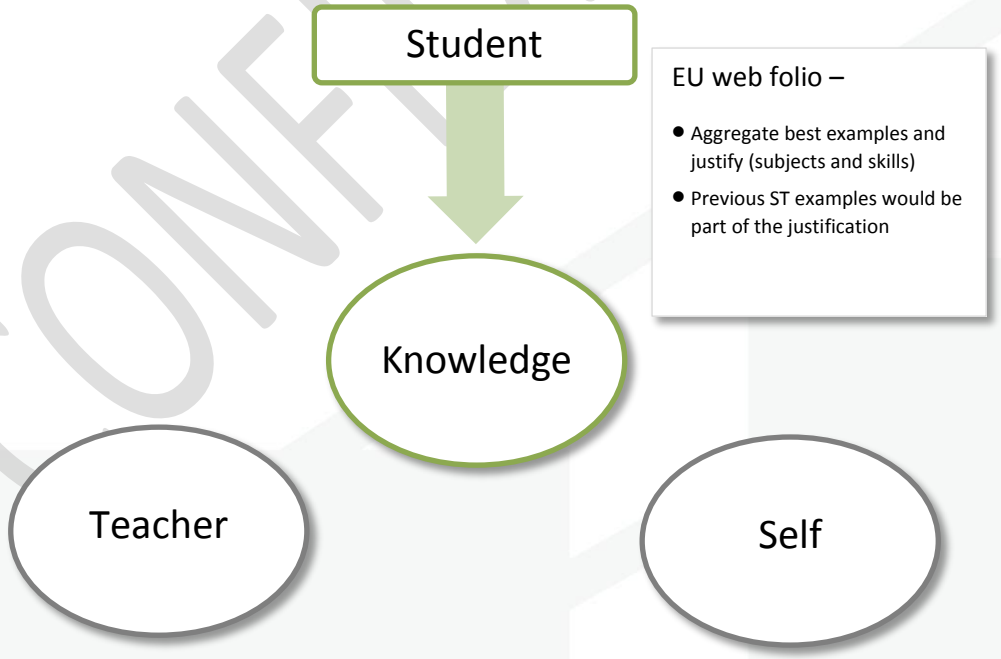


[7]ST because then ST could recommend resources based on student actions.

[9]Ideally this one would be combined with teacher to teacher. As a community tool.

Resources/activities could be voted up and down. Discussion option etc.

5.6.4 Recommendation 5: Student to Teacher/Knowledge/Self



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5.7 Activity Provider Two: Decision

SkillTrack! Teacher Tag has been selected based on the fact that it is an activity provider that is **external** and **complementary** to SkillTrack!

5.7.1 SkillTrack! Teacher Tag Considerations

Learnovate is aware that the choice for this activity provider involves the risk that teachers will most likely be reluctant to use such a self-reflection tool. The main reason for their averseness would be privacy concerns and potential consequences for performance review. Teachers have expressed concerns that their self-reflection data will be tracked and visible to others, for example the principal. Teachers are worried that they will be called to account if they, for example have tagged one skill frequently while they might have overlooked another. These are valid points to raise from a teacher's perspective. Learnovate needs to acknowledge that these concerns might have consequences for the potential to license the self-reflection tool. However, while acknowledging this potential consequence, the Learnovate team has decided to design and develop SkillTrack! Teacher Tag for the xAPI project based on the following arguments:

1. One of the xAPI project objectives is to design **a strong example of an xAPI implementation**. SkillTrack! Teacher Tag*!*, in combination with (dummy) data of SkillTrack! provides that strong example. The combination of the student's tagging and the teacher's tagging will **provide valuable data from a learning design perspective** (teacher's self-awareness).

2. Based on the analysis above, we need to conclude that, first, the SkillTrack! Teacher Tag tool is **the most feasible tool** to design and develop **given the short-term project that xAPI currently is**. The other possible external activity providers need resources (e.g. libraries – recommendation 4) and/or extensive design (e.g. the EU folio – recommendation 5). The feedback A tool (recommendation 3) is a separate tool that cannot provide any valuable integrated data set from an xAPI perspective.

3. The current phase of the xAPI project is for the Learnovate team to explore the xAPI journey, to learn and to be able to provide best practice guidelines to our partners. SkillTrack! Teacher Tag supports this objective by providing a strong xAPI implementation exemplar.

4. Learnovate should be thinking 'out of the box' and **provide innovative EdTech solutions**. SkillTrack! Teacher Tag meets that criterion.

5. We have not conducted **broader market research**. Although Learnovate needs to acknowledge the risk that SkillTrack! Teacher Tag might be hard to trial or license within schools, we have not explored potential opportunities.

6. We need to identify other use cases in a subsequent xAPI project. For example, a corporate use case or a higher education use case. We have not defined specific use cases for these contexts (the current (short-term) project will have a K12 focus) but this will be required in a another xAPI project.

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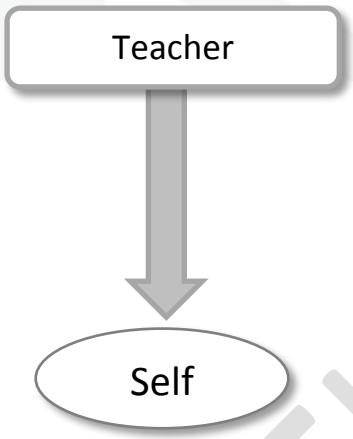
5.8 SkillTrack! Teacher Tag: Implementation Suggestions and Mock-Ups

The original idea was to identify skills within the lesson plan. This does not mean that the teacher will teach the skills explicitly, it only means that the teacher would try to identify beforehand what skills would be covered *implicitly* within the instructional activities that they planned for in their lesson plan. However, it needs to be noted that experienced teachers usually do not create official lesson plans for each lesson; they would input intended skill development for the overall lessons within a scheme of work (unit design). This basically means that the teacher will not have an official tool to track intended skills for each instructional activity.

Name: SkillTrack! Teacher Tag

Activity Provider Objective



The educative relationships covered with this activity provider would be **teacher to self** as it is meant to be a self-reflection tool. The teacher can:

- **compare their tagging with 'expected' skills**
- **compare their tagging with their students' tagging**
- **identify the variety of their tagged skills**
  - identify most frequent tagged skills
  - identify least frequent tagged skills
- **identify tagged skills per subject**
  - for student
  - for teacher

This way, teachers can identify the following:

1. **Overlap/differences in skills tagged (compared to self)**
   When the teacher is designing the lesson plan, they can identify which SkillTrack! skills would most likely be integrated in the planned instructional activity. The teacher can confirm this during the actual instructional activity in the classroom. The teacher can prompt the students to tag skills after an instructional activity and can then themselves 'tag as they teach' as well.

   The teacher can use this type of tagging as a self-check: does their interpretation of what they *thought* would happen and their interpretation of what *actually* happened overlap. This can help to increase the teacher's skill awareness, or, skill literacy.

2. **Overlap/differences in skills tagged (compared to students)**
   The teacher can see to what extent their skill tagging matches with their students' skill tagging. The scenario can be twofold:
   1. The teacher has pre-identified expected skills in their lesson plan. The teacher can track to what extent the students have *actually* experienced that 'pre-identified' skill.
   2. When the teacher tags 'on the fly', the teacher can identify to what extent their interpretation of the skill within the *actual* classroom activity matches with how the students *experienced* the skill(s) that they used in that activity.

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- Note that SkillTrack! is a self-assessment and practice app that focuses on skill *literacy*. When the teacher and the students show a lot of overlap in their tagging, it means that they, first, most likely have had a similar *experience* and that, second, they most likely *interpret* the skill in the same way.

- If the app shows a lot of differences between teacher and student tagging, the teacher can explore the reasons. The teacher can have discussions with the students to identify what they experienced and their reasons for tagging certain skills. This type of discussions can help both the teacher and the students to improve self-awareness and skill literacy.

3. Balance in skills tagged (compared to self)

The teacher can identify what their most common tagged skills are and what their least common tagged skills are. This can help the teacher to identify if they need to make adjustments to the instructional activities in their lesson plans.

4. Skill per Class

The teacher can identify the frequency of skills based on class. This can help teachers identify class trends.

How the app works

The activity provider, SkillTrack! Teacher Tag shows a list of skills on the device that the teacher uses (mobile phone, tablet, desktop), see figures 4-8 for mock-ups of the interface.

1. The teacher logs into SkillTrack! Teacher Tag

2. SkillTrack! Teacher Tag shows the Skilltrack! skills; that is:
   - Collaboration
   - Communication
   - Creativity
   - Information management
   - Self-management

3. The teacher tags the preferred skills during or right after an instructional activity through SkillTrack! Teacher Tag

4. SkillTrack! Teacher Tag knows which class the teacher is teaching at that point (it can identify the group that the teacher is teaching). Because each class usually involves several instructional activities, the teacher would ideally prompt the students to tag after completing an instructional activity. It goes without saying that the teacher should not tell the students *what* skill to tag. Time stamps within the activity providers would be required to be able to analyse the data correctly.

5. SkillTrack! Teacher Tag analyses and visualises the data based on the options above (e.g. visualises the skills tagged by the teacher, the overlap between teacher-student tagging, the differences between teacher-student tagging, tagged skills over time, and so forth.

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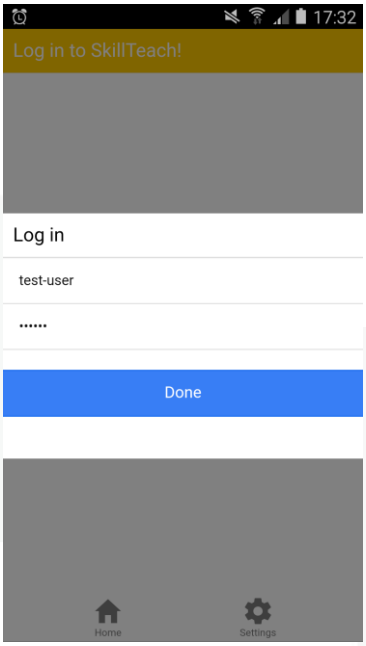

Figure 4: **Login screen** this screen prompts the teacher to enter their KMS credentials. The KMS then verifies the teacher's credentials and issue the app with the user's teacher ID and the LRS credentials for statement requests.

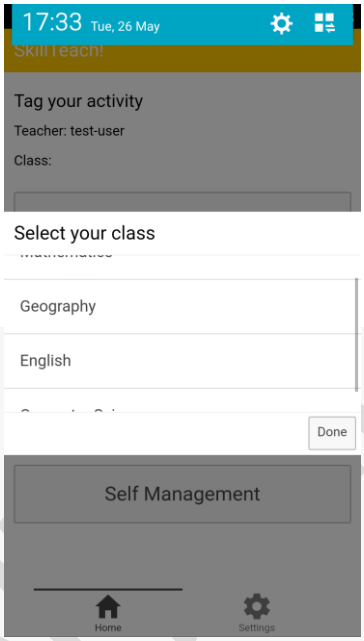

Figure 5: **Class selection screen** this screen prompts the teacher to select the class they want to generate statements about.

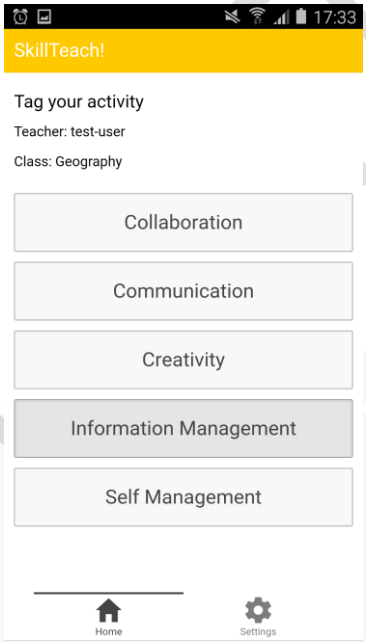

Figure 6: **Home screen t**his screen provides the teacher with a menu to additional screens and a set of tagging buttons.

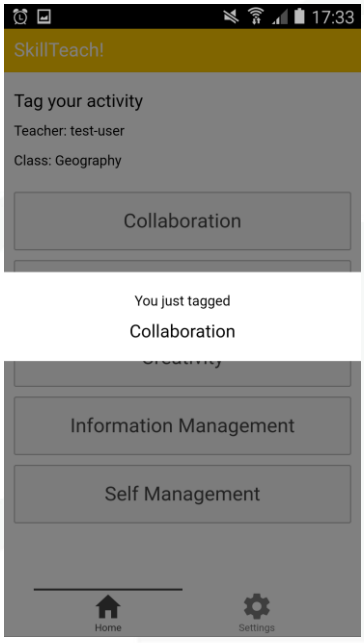

Figure 7: **Tagging screen** this screen informs the teacher that they have generated and submitted a tagging statement.

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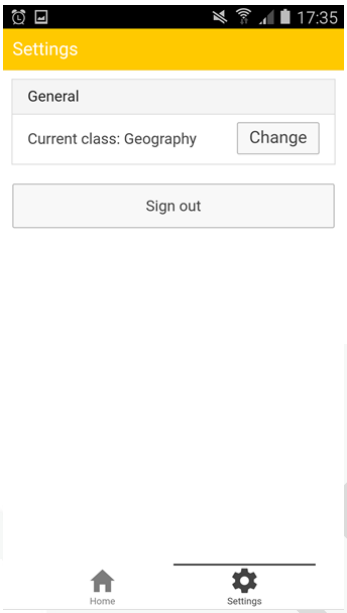

Figure 8: **Settings screen** this screen provides the teacher with an option to change their class or to sign out from the app.

6 Technical Design for SkillTrack!+xAPI

6.1 Introduction

The purpose of this section to collect the output of the design phase of the Learnovate xAPI project from a technical perspective.

Resultantly this section firstly describes the differences between the architecture and functionality of the existing SkillTrack! prototype and the SkillTrack!+xAPI prototype. In addition, all key decisions for the SkillTrack!+xAPI prototype are outlined.

All other documentation of the technical design and and a detailed description of the implementation is contained in the document with the name “Experience API Technical Design Document”.

6.2 Differences and required changes to add xAPI support to the existing SkillTrack! Prototype

One of the main deliverables of the xAPI project within Learnovate will be a prototype implementation, which can be used to demonstrate the ideas, capabilities and goals of xAPI to potential industry partners. In the analysis phase of the xAPI project, the decision was made to re-use the existing SkillTrack! Prototype, and add xAPI support to it.

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This section continues by describing the differences between the architecture of the existing SkillTrack! prototype and the extended 'SkillTrack!+xAPI' architecture. In addition, we will also list the changes which are required for the individual components.

6.3 Changes to the architecture

Figure 9 shows the architecture of the original SkillTrack! prototype. Most notable, there are 3 user-facing applications:

1. The **SkillTrack! tablet application** for iOS and Windows. It is meant to be used by students, and allowed students to learn about five areas of skills, tag their activities in the class room in relationship to those skills, and request badges from teachers to acknowledge their proficiency in regards to these skills.

2. The **Class Manager application** is a Web application. It allows teachers to manage classes and the relationships between teachers, classes and individual students, and to create user accounts from Excel spread sheets.

3. The **Teacher dashboard** is another web application used by the teachers. It allows teachers to monitor the progress of students in their classes. The progress of students is estimated based on the results of automated data analytics of the written responses of a student. In addition, teachers can use the dashboard to award badges.

Regarding the other components of the architecture, the most important component is the **Knowledge Management System (KMS)**, which functions as a broker between the three user facing applications and the backend components. In addition, all data analytics capabilities are implemented as part of the KMS. The KMS uses a **MySQL database** to manage its data. **EVADE** is used to store lesson plans and the information about user roles, and student-class-teacher relationships. The **activity builder** is used to create the content for the SkillTrack! app, such as questionnaires and ranking exercises. The **Open Badges Server** is used to store information about awarded badges and make this information available in an open format. The **Evidence File Server** is used to store files uploaded by the students, such photos and documents.

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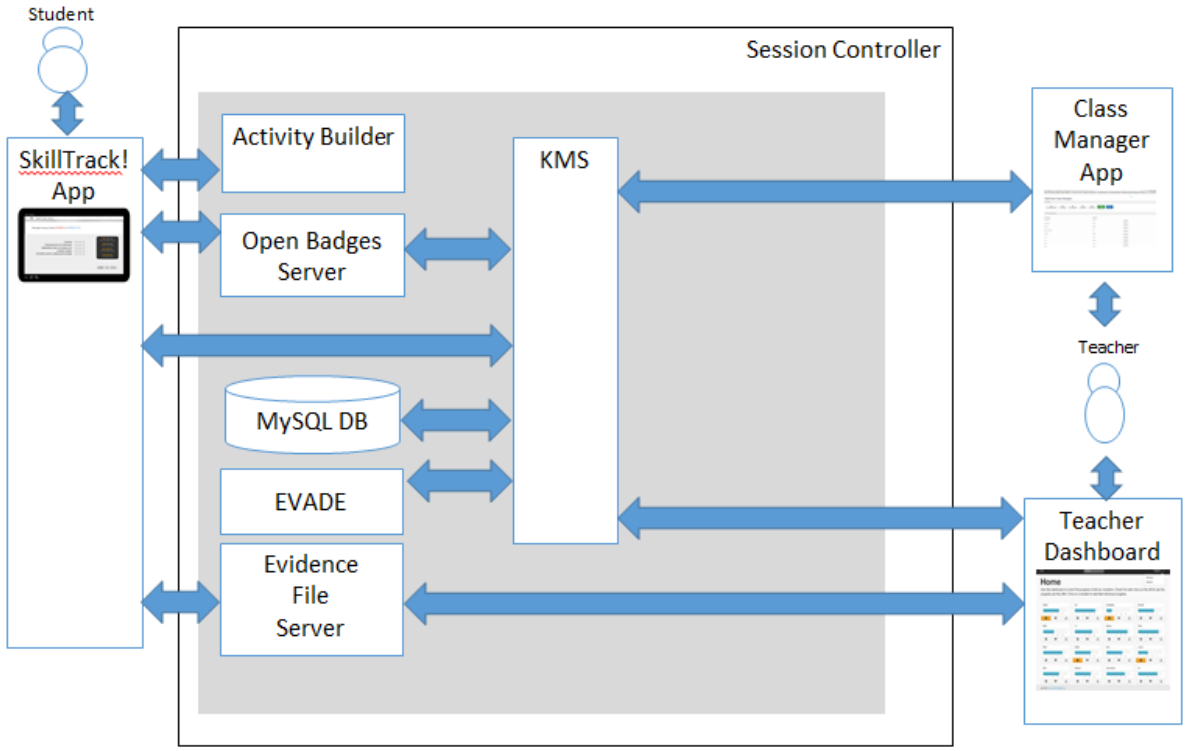

Figure 9: Architecture of the original SkillTrack! prototype

For comparison, figure 10 shows the architecture of the SkillTrack!+xAPI prototype, based on the discussions and technical decisions of the technical team.

There are **two new components**:

1. The **Learning Record Store (LRS)** implements the xAPI standard. It is used to store statements about the "learning experience events" of the students.

2. The SkillTrack! Teacher Tag app for mobile devices. This app is meant to be used by teachers. It allows teachers to tag the skills they are aiming to teach in a class. This data can then be used in the teacher dashboard to compare the skills tagged by the students in a class, with the skills the teacher was trying to teach in the same class. The SkillTrack! Teacher Tag app and associated use case are described in more detail below.

The architecture of the SkillTrack!+xAPI prototype has been chosen in a way, which **minimises the impact of adding xAPI** and an LRS to the existing SkillTrack! prototype. The only two components, which need to interact with the LRS, are the KMS and the SkillTrack! Teacher Tag mobile phone app. As the SkillTrack! Teacher Tag app will be implemented from scratch, the only existing component which needs to be changed to support xAPI is the KMS. This should facilitate finishing the SkillTrack!+xAPI prototype in the limited timeframe of the project.

The technical team has collected all the technical changes, which are required to adapt SkillTrack! to the new SkillTrack!+xAPI prototype. This list of changes can be found in the appendix of this document.

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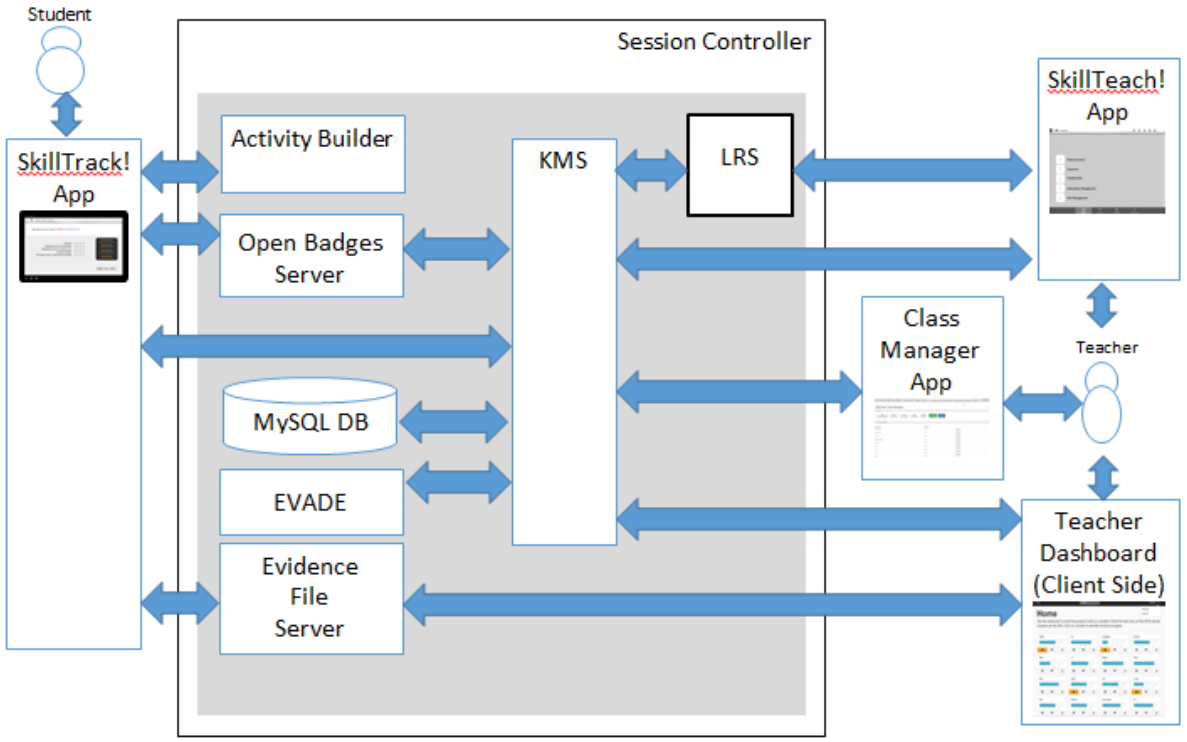

Figure 10: Architecture of the SkillTrack! + xAPI prototype

6.4 Key decisions for the SkillTrack!+xAPI prototype

During the design phase of the xAPI project, several decisions have been made regarding the SkillTrack!+xAPI prototype.

- **Authentication Protocol:** The decision was made to use "basic HTTP authentication" for the SkillTrack!+xAPI prototype. xAPI allows both "basic HTTP authentication" and OAuth to be used by LRS's. The current SkillTrack! prototype already uses basic HTTP authentication. Therefore, the impact of switching from basic HTTP authentication to OAuth was estimated as to much for the short time frame of the project. In addition, the Learning Locker LRS, does not support OAuth, while also being the only available LRS with query capabilities matching the data analytics requirements of the KMS.

- **Approach for Presenting and Visualising xAPI Data:** One of the goals of the xAPI project, is to investigate adding value to xAPI by providing data analytics. As such, the architecture and implementation of the SkillTrack!+xAPI have accommodate both (a) performing data analytics on the xAPI statements in the LRS, and (b) presenting the resulting insights as part of a user facing application. The approach which is currently favoured by the technical team, is to perform the data analytics in the KMS, and present and visualise the insights in the teacher dashboard. This approach would be very similar to the way data analytics are implemented and visualised in the existing SkillTrack! Sticking to this approach should enable completion of this area of functionality in the given time frame. One potential **alternative**, is to use the data analytics capabilities of **EVADE** and apply them to the xAPI statements in the LRS.

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- **Re-use of Existing SkillTrack! Installation:** The decision was made that a completely separate installation with new instances of all existing components in SkillTrack! is required for the SkillTrack!+xAPI prototype. The main reason for this, is that there can be no interaction with the instances of SkillTrack! components which are used in production and as part of the trials. In addition, as data privacy as an absolute must, this will also ensure that no data leakage from therrenlty ongoing trails to the new SkillTrack!+xAPI prototype will occur.

- **Data to use for SkillTrack!+xAPI Prototype:** The team will create dummy data for use by the new prototype. Data gathered during the trails of SkillTrack! can not be re-used due to data privacy and ethical approach reasons.

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Recommendations

Based on the case study and the proof-of-concept prototype implementation, as described in this document, the experience API team has identified the following six recommendations to consider for the industrial partners of the Learnovate Research centre:

7

1. Be clear on **why** you want to use xAPI.
2. **Learning Designers** need to learn to **design for statements**.
3. **Learning Design, Data Analytics and Software Engineering experts** need to collaborate closely.
4. Realise that there will be a **steep learning curve**.
5. Recognise the **need for growth and change management**.
6. **Align privacy/security provisions of xAPI** with legacy and future requirements.

The document "xAPI How To Guide" describes each recommendation in more detail. In particular, in that document we provide a detailed motivation for each recommendation. We also describe how we applied the recommendation to our own proof-of-concept prototype at a high level.

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