Learning Analytics Community Exchange

Towards Learning Analytics Interoperability at the Workplace (LAW Profile)

Learning Analytics Review 5

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Abstract: This paper introduces the needs and possible options for interoperating learning analytics within industrial and corporate scenarios, directly at the workplace. It first introduces general concepts of standardization roadmaps, abstract reference frameworks, application profiles and reference implementations as key steps towards a shared approach to interoperability. It then proposes a scenario-based method to drill down to interoperability needs and options for workplace learning, using a top-down approach. The paper suggests how the community could take action to develop specific profiles and recipes from existing and emerging specifications, with the aim of producing, managing, sharing and distributing standards-based and actionable analytics for improving workplace learning within industrial verticals.
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Executive Summary

This paper builds on earlier work carried out within the LACE project, and reported in Learning Analytics at the Workplace (LAW) a LAW Manifesto (Cardinali & M.Paini, 2015). The Manifesto defined the ‘why’ and ‘where’ of Learning Analytics at the Workplace (LAW) and ‘which’ related policies could help. The present paper moves on to consider ‘how’ new LAW interoperability levels can be achieved.

This paper first introduces the general concepts of standardization roadmaps, abstract reference frameworks, application profiles and reference implementations as key steps towards a shared approach to interoperability. It then proposes a scenario-based method to drill down to interoperability needs and options for workplace learning, using a top-down approach. The description focuses on how the community could take action and develop specific profiles and recipes from existing and emerging specifications for producing, managing, sharing and distributing standard and actionable analytics within industrial verticals.

The paper then ends with a listing of existing specifications from different worlds, suggesting where and why existing specifications from different stakeholder communities could be used as a starting point for a LAW interoperability Profile.

The main conclusions of this Review paper are that:

- The value of Learning Analytics will be in its capability to support workforces in moving away from descriptive and diagnostic observation and towards predictive and prescriptive analysis that is related to the underlying working processes and company goals.
- To be successful at the workplace, Learning Analytics will need to move rapidly away from measuring ‘traditional’ KPIs defined for human observation of formal education (e.g. course attendance, fall out rates, assessments) and towards the automated relation of training and performance support aids into their effectiveness to improve overall process activities and performances.
Introduction

On 15th April 2015 the LACE project, a Community Support Action for the promotion of Learning Analytics (LA) supported by the European Commission, invited its members, associate partners and people interested in Learning Analytics to a workshop in Brussels. The event was designed to discuss and propose possible EU Public Policies guidelines and best practices for fostering Educational Data Mining and Learning Analytics in different contexts, including K12, further and higher education, and industrial and corporate training. At the workshop community needs and interests were recorded by professionals from the LACE workplace learning team (ITS and Skillaware™ from the sedApta™ Group). The result was an initial policy document entitled the LAW Manifesto (Cardinali & M.Paini, 2015) was published to promote the adoption and best use of Learning Analytics at the Workplace (LAW).

Once the LAW Manifesto had defined the ‘why’ and ‘where’ of Learning Analytics at the Workplace (LAW) and ‘which’ related policies could help, it became evident that a more specific and technical document was needed on ‘how’ new LAW interoperability levels could be achieved considering emerging best practices, architectures and interoperability specifications available in a still shaping market. Consequently the present Review paper was generated by the LACE workplace learning team, with the aim of triggering discussion and convergence of the actions and methods needed to move towards shared standards and practices in the sector.

Understanding standards. From pioneering specifications, to ‘de facto’ and ‘real’ standards through profiles and recipes

At present the labour marketplace is developing rapidly, and skill shortages are increasing (Manenti, et al., 2013; Rethinking Education: Investing in skills for better socio-economic outcomes, 2012). In response to this situation, industry must be prepared to embrace and use new, innovative learning technology solutions, making them work with existing corporate IT platforms by means of emerging open interoperability standards. The application of these interoperability standards will enable different learning technologies and solutions to come together to generate new learning ecosystems that can significantly improve training and development practices in the areas of competency, skills and workplace-based learning personalization.

To be economically viable, technologically proven and pedagogically sound, each industry sector must avoid re-inventing the wheel in assembling such ecosystems, but rather rely on state-of-the-art specifications and common best practices in the standardization world. At the same time each sector
needs to be prepared to add its own touch, reflecting the specific needs and uniqueness of its stakeholders.

To clarify this process it is necessary to define the difference between an early stage pioneering RD ‘specification’, a ‘standard de facto’ and a true ‘standard’. The latter is usually issued after voting in official international organisms such as the International Organization for Standardization (ISO)\(^1\) worldwide and the European Committee for Standardization (CEN)\(^2\) in Europe. These organisations represent a wide range of stakeholders, but run the danger of being generic and unfocussed. Specifications usually pass to the ISO/CEN stage of voting and approval, often after an official handover to institutes and associations of communities (such as the Institute of Electrical and Electronics Engineers, IEEE\(^3\)) that are capable increasing awareness, discussion and acceptance of a specification before it enters its official roadmap for final approval of its ‘standard’ status.

Efforts to develop the first generation of learning technologies standards and promote their adoption (Figure 1) have demonstrated that this is not an easy process. The difficulties are largely due to the highly interdisciplinary and multi-sector nature of learning technology standards, and to the fact that not all actors have a pressing economic motivation. Initial specifications have taken between 8 to 10 years from pioneering research and development to full market adoption. Only a few specifications have progressed to the higher stage of final official approval (e.g. the LOM, Learning Objects Metadata, and Content Packaging formats). Early stage specifications started by the EU RD projects Ariadne\(^4\), KOD and Easel from the 90s have only recently, after many changes and adaptations, become official ISO standards as ISO/IEC 19788\(^5\) and ISO/IEC 12785\(^6\) respectively.

\(^1\) [http://www.iso.org/](http://www.iso.org/)
\(^2\) [https://www.cen.eu](https://www.cen.eu)
\(^3\) [https://www.ieee.org](https://www.ieee.org)
\(^4\) Europe’s first relevant attempt at learning technology standardization was initiated as a EU RD project and has now an open foundation, [http://www.ariadne-eu.org/](http://www.ariadne-eu.org/)
The Roadmap of eLearning Standards

From Pioneering RD Specifications to De Facto Market Standards

- Standardization Bodies
  - Level 3: Mass Market Adoption
- Sector Profiling Bodies
  - Level 2: Early Adoption
- Specification Bodies
  - Level 1: Pioneering R&D

- Learning Objects Metadata
- Vocabulary Exchange
- Content Packaging
- Adaptive Sequencing

Aviation
Defence
Medicine
...
Figure 1. First generation learning technology interoperability specifications took between 8 to 10 years from pioneering Research & Development (RD) to full market adoption.
The length of the process is the main reason why the authors of many specifications aspire to creating *de facto* standards, and hope to gain reasonable momentum without ever attempting to enter the standardization path. SCORM (Shareable Content Reusable Model) was developed by NATO’s Advanced Distributed Learning (ADL), and it is one specification that has achieved widespread industrial uptake despite the fact that it never became an ISO standard. Other interesting specifications (e.g. LD, Learning Design from the IMS Global Learning Consortium) never moved beyond niche research due to their complexity, disagreements, and, in many cases, their limited applicability to the real world.

The main indicator for the success of a standard, official or *de facto*, is the pace of its adoption and implementation in real world solutions and platforms. It is therefore essential to cluster stakeholders with high-buying power and provisioning volumes in order to maximise the probabilities of a specification becoming a successful standard. In turn, sector stakeholders are usually interested to engage and experiment with early results in order to ensure that their own needs are reflected when the specification eventually creeps out of early stage pioneering and enters the standardization roadmap. Because of this, all the main industrial verticals, such as Defence, Avionics and Life Sciences, established their own ‘clustering’ initiatives at the start of the learning technology (LT) interoperability era (e.g. the above-mentioned ADL in Defence; the Aviation Industry Computer-based Training Committee, or AICC, then merged into ADL in 2014; and Medbiquitous for Life Sciences).

Sector-related specification bodies are usually private, and they do not see a benefit to waiting for the 10-years standardization roadmap. Rather, they push for wider adoption creating consensus and adoption gatherings amongst stakeholders (e.g. ‘plugfests’), and promote the establishment of shared registries and certification bodies for the specification they want to be adopted. Eventually they try to persuade their members to include the specification as a key requirement in sector procurement exercises and RFX documentation, creating a ‘hockey-stick’ effect in market adoption (Figure 2).
Although these efforts are usually carried out for a specific vertical market sector, they then generate a domino effect by moving into other market verticals that are keen to adopt successful de facto standards without waiting for official ISO and/or CEN processes. These sectors also usually start to aggregate multiple specifications and create terms and vocabularies that can give their own flavour to the selected specification, creating variations on the original terms (usually referred to as 'recipes' and 'profiles' in standards jargon). Profile developers are usually more successful with adoption and exploitation than the original specification bodies themselves, because they free-up time and resources from the initial specification work in order to better support end users and market needs.

The SCORM specification, which we may take to be the most successful learning technologies interoperability specification to date, was a de facto profile of existing IMS (e.g. Content Packaging), IEEE (e.g. LOM metadata) and AICC (e.g. CMI tracking) specifications. The result was a very generic, yet successful, specification for interoperating eLearning contents with third party learning management systems. Although often criticized by many of the bodies which generated its component specifications, it exceeded all of them by achieving a significant level of adoption. This was accomplished by a focus on stewardship, certification and promotion, and by it becoming mandatory to use SCORM in order to participate in large bids for content development and training provisioning in the Defence marketplace in the USA. From this sector it expanded out into other relevant industrial verticals, such as Finance, Banking, Health and Pharmaceuticals. In essence, early SCORM adopters united and clustered within a vertical in order to develop profiles of the existing base
specifications, rather than promoting new ones from scratch. This approach made sector efforts more focused and viable, enabling the vertical sector to generate significant savings. The result was that the members of the vertical were better able to influence the general specification in their interest between the stages of pioneering research and the emergence of a wider market adoption roadmap.

Towards a LAW Profile. Promoting Performance Support and Learning Analytics interoperability standards at the Workplace.

The previous section introduced the various stages needed for official standards to emerge, and discussed the return on investment stakeholders can gain by selecting, embracing and profiling existing specifications and promoting (best) practices at the right moment, rather than by developing new specifications. Given this premise, we now propose a method for the selection of existing specifications that can be used for workplace performance support and learning analytics, and for aligning, profiling and promoting them in meeting the needs of the industry. The method takes into consideration the fact that specifications will be sourced from different worlds (given the inherently inter-sectorial nature of analytics) and so it focuses on aligning efforts to relate learning analytics to process performance indicators and vice versa.

The method starts with the definition of possible future workplace scenes, called LAW Future Scenarios, in order to highlight not only the needs of today, but also those possible in the near future, given the 8-to-10 years frame usually needed for new interoperability specifications to become strong(er) and succeed in industry. We invite readers to submit their own vision of future LAW Scenarios, Ecosystems, Specification listings and sample implementations, on an ongoing basis. This can be done by writing to the contact mail provided at the end of this review paper.

LAW Future Scenarios

This paragraph introduces the first two LAW Scenarios, not with the intention of being comprehensive, but rather to trigger other stakeholders to formalise their workplace interoperability needs by using a similar method. In order to contribute to this process, each scenario should have the following elements.

1. **LAW Scenario Narration.** A detailed and imaginative description of the scenario.

2. **LAW Scenario Ecosystem.** An Abstract Reference Architecture, capable of implementing the scenario described in (1), defining its possible sub-components and boundaries.
3. **LAW Worlds Identification & Specs listing.** A graph listing the IT Worlds touched upon by the LAW Ecosystem described, and a table of existing or emerging specifications and related bodies with their pros and cons, possible use, and limits for assuring the interoperability needs emerged in (2).

4. **LAW Ecosystems Reference Implementations.** A list of initial implementations, possibly partial or incomplete, that illustrate real life feasibility and the advantages of merging some of the multi-sector specs listed in (3).

The following paragraphs sections each step listed above for two initial LAW Scenarios.

**Step 1: Describing LAW Scenarios**

In this section, two sample future workplace-learning scenarios are introduced. We decided to use an 8 to 10 year time span as the horizon for enabling new and emerging interoperability specs to be experimented with, profiled and finally adopted by the wider community.

**LAW Scenario 1: Wearable Maintenance Support**

Here, we describe an illustrative ‘day in the life’ of a smart manufacturing operator called John, who is using an LA enhanced wearable device while performing a maintenance routine within a large multinational and multilingual manufacturing organization in 2020.

It’s John’s first working day on the new assembly line at the Avionics factory plant. Before going live in his engine repair task, he reviews all the process and task information he has available. New plant equipment, processes and procedures have been fully illustrated and tried out in classroom and in online training sessions, but now John is confronted by the real thing. He really misses his coaching friend! The company has offered him its new BYOD (Bring Your Own Device) support, which lets him bring his up-to-date Android tablet to work, but this cannot be used for this task. The data must be secure because it comes from the new MaaS (Manufacturing as a Service) Cloud provided by central headquarters. Entering the assembly line he can choose between picking up a handheld rugged computer or a new wearable head mounted device, both working with a secure, Wi-Fi enabled connection to the company cloud-based Intranet. Both devices come with the pre-installed AHMICO App, a brand new support system promising to support John with a real time Avatar that accompanies him as he enters the assembly line, becoming his virtual assistant. The IT managers explain to John that the device brand AHMICO stands for ‘Augmented Human Manufacturing Intervention in the Cockpit’ but also that it sounds like a less scary ‘FRIEND’ in Italian. He feels a little less intimidated, and opts for the head mounted version, because he will need to perform hands-free operations once on the assembly line. Wearing AHMICO feels as light as a normal pair of working glasses, with no cabling or constraints. As soon as John has put on the AHMICO goggles, they ask him to summarize his active process and task, and if he needs anything in particular. The System automatically checks the user language, role, skills, and data needed for interactions with the plant SCADA and
MES interfaces in order to infer the best avatar styles and layout for John. “First day on the line with this new model...” says the virtual assistant “it’s normal if you need some support..”. It is as reassuring as the coach John left back in the training lab. The AHMICO goggles understand that John has recently been under-performing a little, although he has a long track record of successful maintenance accomplishments. The system sets itself up to guide him step-by-step through the process and tasks he has to accomplish, giving him the extra attention he deserves. After logging into the factory MaaS infrastructure, the AHMICO virtual tutor loads several multimedia assets that will be needed to support John during the process, task and procedure he has to accomplish. The additional data streams are mashed up from the factory MES and SCADA software, providing John not only with live support but also all the complementary data sets he needs to perform his task. John starts working with his hands free, and the virtual assistant guides him through the step-by-step instructional plan he has to follow. In a side corner of the display John is offered, clearly but discretely, a full library of training materials and technical documentations waiting for his help requests. When John comes up against a problem in the repair task he shouts “Please help!”, and the AHMICO Assistant steps in. The goggles slide in a ‘Panic’ button offering an augmented view in front of him, including a quick reference to short training videos and documentation aids perfectly overlaid on the new machinery in front of him. Operational field data are also needed, but John is not concerned. Whenever he wants, he can call ‘Data up’ to the AHMICO assistant and access an online analytics dashboard. Finally John accesses a one-minute fast training simulation through the procedure, enjoying playing his decisions in protected game mode before doing the real thing. After 30 minutes wearing the AHMICO goggles, John is now much more confident with his new task: he knows how to deal with the new plant layout, how to take action, and how to report data by sending voice notes to the Plant MRP system. All Human to System and System to Human interactions and activities are tracked and exchanged via the Learning Analytics bus and Manufacturing Intelligence modules. This data is used to infer analytics on the user experience and performance, in order to continuously improve and adapt the AHMICO support layers for the end user. Having felt confident and comfortable, as if it had been a face-to-face experience, John now understands the value of the new company system and above all...why they called it AHMICO!
LAW Scenario 2: Digital Process Support

Here, we describe an illustrative ‘day in the life’ of a software developer using an LA enhanced Performance Support platform in a software engineering lab within a large multinational and multilingual setting in 2025.

It’s Mary’s first day on a new Software Project at her software engineering lab, which is piloting distributed crowd development with a new customer. Before going live in her development task, she reviews all the process and task information that she has been given. The new customer, new software tool and new processes and procedures have all been fully explained and tried out in online training sessions, but now Mary is confronted by the real thing! The company is using a new crowd-based code development system, a collaborative platform that enables Mary to engage with authorized external developers to co-develop new programs. The service automatically authenticates and profiles Mary both via her Social BPM online, but now Mary is confused by the real thing.

She enters the process workflow she has to use and decides to work on a debugging task. She logs in through a secured, face recognition-based password and connects to the company Social BPM & Performance Support platform, which is ready to start when needed. Mary’s device comes with the pre-installed new App named CoCoon, which stands for Context aware Collaboration online, but Mary prefers to recall the butterfly’s protective environment. CoCoon is a new assistive technology that promises to train and follow her with real time advice and support to manage any odd case or exception she might encounter in her workflow. She really hopes that the new app will help her out, and provide a ‘cocoon’ feeling! The task picked by Mary requires a new development tool with new procedures, but the CoCoon assistant can be called up simply by calling its name, so Mary feels confident to start it up. The CoCoon assistant displays the objectives, timing and outcome expected for her task. The social network feature of the platform immediately provides short lists drawn from her network friends and company peers who have the skills and time to help her out as needed. Learning analytics works in the background to track all of Mary’s steps and match them against best performing benchmarks in order to provide her with additional guidance and support as needed.

After an hour of development work, Mary gets stuck. She is not sure of all the steps and routines needed to accomplish the new task. The CoCoon Assistant pops up and asks Mary to speak her request. Mary feels a little unsure, but she assumes she can speak to her new ‘friend’ in an informal and conversational way, as if it was a human assistant. “Hi there, I don’t know how to do this task with this new Software tool. Do you have any procedure support guidance in your repository? Can you help me?” The CoCoon Assistant takes a little (machine) time to go back to the database of actionable tasks, reasons on Mary’s request and infers the best sequence possible based on the evidence of other developers of the network having
exchanged similar reasoning and having solved similar cases in the recent past. CoCoon gets back to Mary in two seconds and replies “Please follow me now on screen and I will show you how it works”. CoCoon also sets up a quick reference interface displaying a selection of the documentation used by the other teams who tried out the same task before, and displays peers and friends amongst Mary’s network connections who have the skill set and knowledge to possibly assist her. Mary is happy that she did not receive the usual response of “Hi Mary, submit your ticket and you’ll get an answer within next 4 working hours” that she got from the old system in her organization. She finishes the procedure 50% more quickly than the time scheduled by the benchmark workflow in the company’s BPM system. Mary thanks the friends who helped her out, and approves their work outcomes to the company’s crowdsourcing payment system. She proudly reports her success and satisfaction to the CoCoon assistant, speaking out the lessons learnt and the most useful tips she has received. Cocoon thanks her, and updates its Adaptive Case Management knowledge base with the new solved case. Mary is satisfied: she now not only knows how to deal with the new task and tools, but has also found new programming friends and a trusted virtual assistant.... at the press of a button! Mary has felt confident and comfortable, as if it had been a face-to-face experience, and now she understands why they called it CoCoon!

Step 2: Detailing LAW Ecosystems

Having given an extended imaginative description of possible future workplace scenarios, the second step defines possible abstract reference architectures. We call these ‘LAW Ecosystems’, and they show the components and subcomponents that could be used to implement the described scenarios. The intent is not to provide a detailed implementation plan, but rather to identify where analytics are engaged and where interoperability needs might emerge. Figures 3 and 4 visualise the results obtained for LAW Scenarios 1 & 2 described above.
LAW Abstract Reference Ecosystem – Scenario 1
Augmented Process Performance Support Scenario for Plant Manufacturing

Figure 3. Sample LAW Ecosystem 1: Augmented Process Performance Support Scenario for Plant Manufacturing.
LAW Abstract Reference Ecosystem – Scenario 2
Augmented Process Performance Support for Enterprise Software Delivery

Figure 4. Sample LAW Ecosystem 2: Augmented Process Performance Support Scenario for Enterprise Software Development.
If we analyse the architectures in Figure 3 and 4, we can identify the IT Systems Worlds which need to come together to implement the scenarios. Figure 5 represents the result of this analysis with arrows representing the possible influence each world will have on the use of analytics within the proposed ecosystem, and which may require system interoperability and data exchange capability.

**LAW Scenarios 1 & 2 – Underlying Worlds & Analytics Influence Trends**

![Diagram of Underlying IT Worlds and related analytics interoperability needs for Sample LAW Scenarios 1 & 2.](image)

The main conclusion emerging from these two sample scenarios, is that the World of Learning Technologies is likely to be less influential than the other Worlds in terms of the semantic terminology and values to be expressed in analytics. In fact the underlying industry Worlds addressed in these two scenarios (i.e. the Manufacturing, Supply Chain & Software Engineering Worlds) have been using advanced analytics and data mining techniques for more than a decade to support process measurement, monitoring and improvement to date, and by 2020 it will be nearly two decades (Cobbold & Lawrie, 2002). For example, today the area of manufacturing intelligence and analytics is one of the fastest growing sectors in Business Intelligence. Manufacturing organizations have used key performance indicators to evaluate their success, or to evaluate the success of a particular activity in which they are engaged since the 1990s (Fitz-Gibbon, 1990). Since then the use of KPIs within process modelling and improvement has moved forward a long way in manufacturing now starting to be standardised by sector associations, one of the main ones being the International Society for Automation, or ISA.\(^{11}\)

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\(^{11}\) https://www.isa.org/
ANSI/ISA-95, or ISA-95 as it is more commonly called, is an international specification developed by ISA that includes also several references to performance measurements and indicators within industrial manufacturing processes\textsuperscript{12}. It defines a five-layer abstract reference model (Figure 6) for manufacturing automation describing the plant environment and its operations from low level ‘machine to machine’ automation to high level ‘business to manufacturing’ transactions. ISA-95 (ISA 95, 2015) includes sections describing and standardising performance analytics and key performance indicators (KPIs) to be applied in all industries, and in all sorts of processes, like batch, continuous and repetitive processes.

\textbf{Figure 6. The ISA-95™ Manufacturing Model by ISA™.}

The value of a model like ISA-95 has been to underpin an analytics standardization culture in industry, with the aim of unifying and harmonizing definition and measurement of performance indicators, in a continuous drive towards persistent improvement and appraisal of processes, usually called ‘maturity modelling’.

It will be a crucial success factor for LA in Industry that it should be able to ‘observe and measure’ the efficiency and effectiveness of new training solutions whilst matching them to the specific KPIs of the processes they aim to support in the workforce (Aiman-Smith & Green, 2002). This is particularly true when executives from the Human Resources and Training departments (e.g. Chief Learning Officers and Senior Vice Presidents for HR) are asked by their IT and Finance counterparts to justify the need to invest in new LT solutions, and in the integration of LT solutions in the cockpit or directly at the workplace.

With this premise, Step 3 will analyze specific LAW Scenarios, investigating pre-existing models and specifications that can be used to measure and

\textsuperscript{12} \url{https://www.isa.org/store/the-road-to-integration-a-guide-to-applying-the-isa-95-standard-in-manufacturing/116016}
improve the processes which are the basis of the underlying worlds we intend to target with the future LAW Ecosystem. This is the case for Manufacturing in LAW Scenario 1, where an application for learning analytics would not be complete or viable without considering its relationship with the concept of performance and skills expressed in the ISA-95 specification. Similarly, in the case of Software Engineering in Scenario 2, many sectorial specifications and modelling initiatives already exist. These include the Trillium Model\textsuperscript{13} developed by Bell for the Telecom Industry or the CMMI model\textsuperscript{14} developed by the Software Engineering Institute (Figure 7), and eventually generalized in the Spice (ISO 15504)\textsuperscript{15} standard for measuring maturity levels and capabilities in industry processes and skills.

With this background, it is evident that, if such scenarios are to be successful, new LAW ecosystems must be capable of aligning learning metrics with process aspects when dealing with industry maturity modelling (Cardinali, et al., 2014).

When scenarios address value chains and providers, such as those described above, it is important to consider another cross-industry specification, the SCOR & DCOR modelling approach. This sets out Supply and Delivery Chains processes, resources and key performance indicators (Figure 8) developed by the Supply Chain Council (SCC) and currently managed by the professional association for supply chain and operations managements APICS\textsuperscript{16}.

\textbf{Figure 7. The CMMI™ Software Production Model by the Software Engineering Industry (Carnegie Mellon).}

\textsuperscript{13}https://en.wikipedia.org/wiki/Trillium_Model
\textsuperscript{14}http://cmmiinstitute.com/
\textsuperscript{15}https://en.wikipedia.org/wiki/ISO/IEC_15504
\textsuperscript{16}http://www.apics.org/
SCOR has been a very relevant model for defining the value of metrics in continuous process improvement. It has promoted a culture of process best practices and KPIs and their cross relation by means of what has been called “metrics technology” guiding how market vendors could develop applications capable to measure field data then mapped into high level financial and organizational indicators. Based on such open approach, leading vendors (e.g. SAP ERP) have made their success by going to market with tools defined as “Scor Compliant”.

SCOR & DCOR Models
Introducing Process Best Practices & Metrics Technology

Figure 8. The SCOR/DCOR Supply & Distribution Models by SCC/APICs.

Step 3: Identifying, Listing & Aligning LAW Interoperability Specifications
Previous samples demonstrate how continuous performance improvement is a necessary strategic service in any industrial context. The value of data and deep understanding when taking a decision to improve performance is evident in the results achieved by experts engaged in redesigning processes based on their heuristics (Figure 9).
The relevance of informed observation and deep understanding in decision-making.

The introduction of automation, and the general availability of expertise to take informed decisions rather than biased guesses, will be one of the key selling points for promoting LA in Industry.

The main value of Learning Analytics will be in its capability to support workforces in moving from descriptive and diagnostic observation into predictive and prescriptive analysis (Figure 10).

Hence, we will be able to promote Learning Analytics at the workplace only if and when we are able to interoperate new learning technologies with process management and analysis levels. To do this Instructional designers will need to study and master methods for designing and implementing Performance Indicators Systems (PIS) for industrial organizations and processes such as Ecograi (Doumeingts, et al., 1995). Linking training to organizational KPIs, will demonstrate that new training initiatives and platforms are useful in helping the organization and its workforce gain new levels of maturity and proficiency in their never-ending quest towards process excellence. This will require the introduction of new levels of vertical interoperability, not only within the specific LT World, but also, and most importantly, amongst the different analytics Worlds present in the target scenarios LT solutions to be addressed.
In particular LT-related KPIs and measurement methods and models will need to relate to the respective KPI and analytics modelling approaches present in the Worlds that they seek to enhance. In so doing the efficacy and efficiency of the proposed LT solutions can be related to improvement in the underlying process levels. In this respect it is worth highlighting that the well-known ISO 9000 series for Quality processes in Organizations is adding hooks for Process and People performances as main pillars in its 2015 revision\textsuperscript{17}.

**To be successful at the workplace, Learning Analytics will need to move rapidly from measuring ‘traditional’ KPIs defined for human observation of formal education (e.g. course attendance, fall out rates, assessments) to an automated relationship between training and performance support aids and their effectiveness in improving overall process activities and performances.**

With this goal in mind, the final step of the proposed LAW Profiling methodology is to map the LAW Scenario Worlds identified with a set of specification bodies active in the reference world developing metrics and performance measurement methodologies and vocabularies. This is done graphically in Figure 11 and in a listed form in Appendix 1 (List of possible specifications and standards related to Workplace Learning).

Appendix 2 (List of reference Workplace Learning Ecosystems) finally includes a section listing projects and/or commercial platforms and systems, using at least a couple of the specifications listed in Figure 11 coming from different Worlds, to build open and interoperable ecosystems for the benefit for real users.

\textsuperscript{17} \url{http://www.iso.org/iso/iso9001_revision}
Figure 11. Example of Interoperability & best practices available for LAW scenarios 1& 2.
Conclusions

Convincing industry executives of the benefits of new learning technologies will always involve assessment of the changes they will bring about, and improvements to underpinning production, distribution and management processes. This assessment will detect successes and pitfalls, and above all the ROI for the adopted solution.

Moreover, if we want to promote learning analytics in the industrial workplace, we will need to relate the measurement of training to the measurement of the processes that we intend to support.

This may be done by choosing the right KPIs for measuring, monitoring and assessing training, and by measuring improvements introduced by the suggested changes. These KPIs should be relevant to the organization, and always bear in mind the different Worlds and related corporate departments which will be responsible for approving the performance gain.

The present Review has presented a methodology to define future LAW scenarios, infer possible implementation ecosystems, identify underpinning IT worlds and relate them and their approaches to the different analytics worlds that might be touched.

Finally, an initial listing of sample piloting implementations has been introduced describing their use of listed standards and interoperability points and letting this open for future contributions via the LACE portal and Evidence Hub.
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About

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About the author

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<th>Fabrizio Cardinali is one of the EU's leading technology enhanced learning solutions entrepreneurs and interoperability standards experts. After helping to start, position and sell several learning technologies companies world wide (e.g. Giunti Labs, eXact Learning NA in the US and Harvestroad Hive in Australia), Fabrizio is today CEO of Skillaware (<a href="http://www.skillaware.com">www.skillaware.com</a>) a new generation Performance Support &amp; Learning Analytics solution for workforce training and engagement during the roll out of new software platforms and procedures. Fabrizio leads WP5 (Workplace Learning) activities in the EU LACE Initiative.</th>
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<td>Fabrizio Cardinali</td>
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Citation


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http://www.laceproject.eu
APPENDIX 1: List of possible specifications and standards related to Workplace Learning
List of relevant interoperability standards from different educational and industrial fields.

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<thead>
<tr>
<th>Specification</th>
<th>Short Description</th>
<th>Use in Scenario</th>
<th>Limitations &amp; Possibilities</th>
<th>URL</th>
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</table>
| **1.** Name: xAPI  
Emitting Body: Advanced Distributed Learning (ADL)  
Purpose: Learning Analytics (Corporate/Industry) | The xAPI is a specification that describes an interface and the storage / retrieval rules that developers can implement to create a learning experience tracking service. The service works by allowing statements of experience (typically learning experiences, but could be any experience) to be delivered to and stored securely in a Learning Record Store (LRS). The format of these statements is based on Activity Streams (Actor, Verb, Object; e.g. “I did this.”). In this format, the Actor is the agent the statement is about, like a learner, mentor, teacher, or group. The verb describes the action of the statement, such as read, passed, or taught. And the object is what the Actor interacted with, like a book, a test, or a class  
(Source: ADL http://adlnet.gov/tla/experience-api/background-and-history.html) | xAPI could be used in the LAW ecosystems to continuously track user activity and to exchange data with the HR/LD department hosting a centralised database tracking user performances (e.g. LRS, Learning Records Store). | Whilst xAPI is a very suitable specification for tracking any user activity, it will need a way to hook in vocabularies of verbs and actions to be truly interoperable. Verbs might come in ontologies or taxonomies using RDF or XML like formats. The VDEX (Vocabulary exchange) specification from IMS could be considered for the purpose. | [http://adlnet.gov/capabilities/tla/experience-api.html](http://adlnet.gov/capabilities/tla/experience-api.html) |
| **2.** Name: CMIS | CMIS is a ‘profile’ for using the xAPI specification with | CMIS could be used in | Although CMIS extends and | [http://www.adlnet](http://www.adlnet) |
### Promoting Learning Analytics Interoperability at the Workplace

| **Emitting Body:** Aviation Industry CBT Committee (AICC) / Advanced Distributed Learning (ADL) | traditional learning management (LMS) systems. Since the xAPI specification is highly generalized to support many different use cases, a set of ‘extra rules’ (called a ‘profile’) is needed to ensure interoperability for a given use case. The cmi5 profile ensures plug and play interoperability between learning content and LMS systems. The use case that the cmi5 profile is specifically designed for is one where the learner launches the learning content/activity from the LMS user interface. (Source: CMI5 Project GitHub) | LAW ecosystems to increase xAPI interoperability with:  
- Remote Support Launch Mechanism  
- Authentication  
- Session Management  
- Reporting  
complements the previous AICC tracking formats it still mainly relates to packaged contents. Combining CMI5 with XAPI would enable to extend the launching mechanisms for performance aids and agents not using the LMS as a launch mechanism but as receptor of the tracking data. | t.org/capabilities/next-generation-scorm/cmi5.html |
| **Purpose:** Learning Content Tracking (Corporate/Industry) |  |  |  |

3. **Name:** Caliper  
**Emitting Body:** Instructional Machine Systems (IMS) Global Learning Consortium  
**Purpose:** Learning Analytics (Education)  
Caliper Analytics™ is a new interoperability specification for educational click stream analytics created by the IMS Global Learning Consortium for the education community. Major educational suppliers are using Caliper to collect millions of events every week and the data is helping to shape teaching and learning on multiple levels. Several leading institutions are also working on putting Caliper in place.  
Caliper Analytics provides more than a specification. Caliper also provides open source code and APIs (the Sensor API™) to enable rapid implementation of the standard.  
The **Caliper standard:**  
- Establishes a means for consistently capturing and presenting measures of learning activity, which will enable more efficient development of learning analytics features in learning environments  
Caliper could be used in the LAW ecosystems to bridge the workplace learning scenarios to specific vocabularies and metrics for Educational and Vocational training. It could also be a valid model for expressing vocabularies and exchange mechanisms, which are missing to date in xAPI.  
Caliper and xAPI are both emerging specifications which are very useful for the Learning Analytics interoperability. Rather than competing and duplicating functionality, they should be aligned in layers. One should provide the syntax for tracking learner activities and the other the semantics of those activities. |  |  | http://www.imsglobal.org/caliper/caliperv1p0/ims-caliper-analytics-best-practice-guide |
| (continued) | • Defines a common language for labelling learning data, which will set the stage for an ecosystem of higher-order applications of learning analytics  
  • Provides a standard way of measuring learning activities and effectiveness, which will enable designers and providers of curriculum to measure, compare and improve quality  
  • Leverages data science methods, standards and technologies  
  • Builds upon existing IMS standards  
  • Direct access to the LMS captured events as they occur  
  • Use of scalable, commercially available messaging streams  
  • Support for real-time messaging intervention use cases  
  • Support for supplier-specific metric profiles  
(Source: http://www.imsglobal.org/initiative/real-time-cross-application-educational-data-and-analytics) |
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<th>Name: ISO22400</th>
<th>ISO 22400 specifies an industry-neutral framework for defining, composing, exchanging, and using key performance indicators (KPIs) for manufacturing operations management (MOM), as defined in IEC 62264 1 for batch, continuous and discrete industries. Currently KPIs are 34 and each KPI is defined though a formula, a time model and an effect model. The spec also defines how a KPI may be exchanged from one MOM application to another, or from a MOM application to other enterprise applications in the business domain. The KPI exchange may occur periodically, be event-driven, or be on demand. In order to realize the interoperability of the applications, these applications shall have access to the formal KPI templates. Part 3 of the ISO 22400 will discuss the exchange issue in more detail and will define a formal KPI template using UML. This is an example of standardising KPI semantics description and exchange for a specific market vertical (Manufacturing Operations). (Source: ISO website)</th>
<th>ISO 22400 could be used in LAW ecosystem 1 to model the specific KPI semantics of the manufacturing processes . ISO 22400 includes some UML descriptors and exchange mechanisms, but presumably XSLT transformations and/or RDF relations should be set to relate process KPIs to learning KPIs.</th>
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<td>Name: SCOR/DCOR</td>
<td>Supply-chain operations reference-model (SCOR) is a process reference model for supply chain management. This reference model enables users to address, improve, and communicate supply chain management practices within and between all interested parties in the extended enterprise. The supply-chain operations reference-model was initially developed in 1996 by the management consulting firm PRTM, SCOR and DCOR could be useful in mapping and measuring process performance in supply and delivery activities related in the LAW ecosystems. In LAW Ecosystem 1 SCOR SCOR and DCOR models define which KPIs are relevant to exchange in an open and interoperable abstract architecture (SCOR levels 1-3). These models then require vendor specific implementations (e.g. SAP) to pass data to the IT interoperability and</td>
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<td>Emitting Body: International Standards Organization (ISO)</td>
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<td></td>
<td>Purpose: Process KPIs for Manufacturing Optimization</td>
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<td></td>
<td>Emitting Body: Supply Chain Council (SCC) / Association for operations management (APICS)</td>
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### Purpose: Reference Model for Supply and Distribution Chains management and performance measurement

Now part of PricewaterhouseCoopers LLP (PwC) and AMR Research, now part of Gartner, and endorsed by the Supply-Chain Council (SCC), now part of APICS, as the cross-industry de facto standard strategy, performance management, and process improvement diagnostic tool for supply chain management. The SCOR model contains more than 150 key indicators used in conjunction with performance attributes to measure the performance of supply chain operations.


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### Name: DITA
**Emitting Body:** Open Association for Standards in the Information Society (OASIS)

**Purpose:** Technical Documentation creation and management specification (also available for Learning)

The DITA OASIS Standard defines an XML architecture for designing, writing, managing, and publishing technical documentation in print and on the Web. DITA (commonly pronounced dit’-uh) builds content reuse into the authoring process for document creation and management. …

Focusing on a common topic model as a conceptual unit of authoring, DITA provides a core set of topic types derived from concept, task, reference, troubleshooting, and glossary. DITA defines a specialization mechanism for extending mark up to represent either new topic types or new domains of mark up common across sets of topic types. DITA maps can combine topics into various kinds of deliverables. Content DITA could be used for all the training and technical materials to be used in the LAW Ecosystems. Being specialized for several industry verticals, including help and training materials, it may be the best common specification for Knowledge documentation exchange within the LAW ecosystems

Although DITA can easily be adapted for any sector vertical it does not include any feature for launching and tracking information. It should be matched with xAPI and CMMI5 to provide better distribution of actionable contents with embedded user tracking capabilities to generate analytics.

## 7. BPMN

**Emitting Body:** Object Management Group (OMG)  
**Purpose:** Business Process Modelling

Business Process Model and Notation (BPMN) is a standard for business process modelling that provides a graphical notation for specifying business processes in a Business Process Diagram (BPD), based on a flowcharting technique very similar to activity diagrams from Unified Modelling Language (UML). The objective of BPMN is to support business process management, for both technical users and business users, by providing a notation that is intuitive to business users, yet able to represent complex process semantics. The BPMN specification also provides a mapping between the graphics of the notation and the underlying constructs of execution languages, particularly Business Process Execution Language (BPEL).  

BPMN could be used in all LAW ecosystems to provide a means of describing and interoperating Business processes within the scenarios

Whilst BPMN describes processes and workflows it has no embedded specification for content management or KPI tracking. It could be combined with DITA and xAPI to provide the workflow structure on which DITA contents and xAPI statements could be mapped. This would enable Content Access and User Performance to be related to specific sub processes and tasks in the reference workflow.

http://www.omg.org/spec/BPMN/2.0/

## 8. ISA95

**Emitting Body:** The ISA 95 spec was developed by a group of companies (e.g. Honeywell, Sequencia, Foxboro, Yokogawa, Fisher

ISA-95 is particularly suited for describing the

ISA-95 provides the semantics for mapping low-level metrics to high

https://www.isa.org/isa95/#sthash
| International Society of Automation (ISA) | Rosermount, Chevron, Dow Chemical, SAP and many others | Manufacturing scenario in LAW Ecosystem 1. It provides all the levels of abstraction for passing from machine to machine and IoT levels, up to high-level financial and managerial abstraction of processes and related KPIs. | end KPIs understandable at organizational and financial levels. But it lacks a focus on the learning and skills levels. This could be resolved by relating specific ISA 95 structures to learning goals and objectives, and then tracking them with XAPI and/or Caliper. |
| **Purpose:** Enterprise modelling and information exchange for manufacturing automation | **to:**  
- Define in detail an abstract model of the enterprise, including manufacturing control functions and business functions, and its information exchange.  
- Establish common terminology for the description and understanding of enterprise, including manufacturing control functions and business process functions, and its information exchange.  
- Define electronic information exchange between the manufacturing control functions and other enterprise functions including data models and exchange definitions.  
(Source: http://isa-95.com/. Accessed November 2nd, 2015) | ISO/IEC 15504 could provide support defining and measuring the maturity models within the LAW Ecosystems giving an overall assessment of the organization’s capabilities to perform well. |

Name: ISO/IEC 15504/SPICE  
**Emitting Body:** International Standards Organization (ISO)  
**Purpose:** Process Maturity modelling  
These are several official standards or de facto standards from specific verticals defining a reference model to describe process maturity levels and related capabilities for each dimension. Related practices then offer unified and shared Key Performance Indicators (KPIs) to be measured and monitored for appraisal and possible certification of new maturity models. Many have related public or private bodies releasing certificates on the levels.  
ISO/IEC 15504 Information technology — Process assessment, also known as SPICE (Software Process ISO/IEC 15504 could provide support defining and measuring the maturity models within the LAW Ecosystems giving an overall assessment of the organization’s capabilities to perform well.  
ISO/IEC 15504 contains an abstract reference model capable of defining a process dimension and its maturity level. However, specific modelling standards might be more appropriate for each specific LAW Ecosystem. For example the CMMI, Trilium and ISA 95 include approaches which might be more suited than ISO 15504 when dealing with Software, Telco and


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ISO 9001 could provide the levels of abstraction for relating learning and process KPIs to quality performance inside organizations. The new ISO 9001 2015 version adds Peoples Skills and Processes to the equation and hence could be used to add Quality measurement to the overall ecosystem.

ISO 9001 is very popular and adopted, but it is a very lengthy and paper-based workflow and methodology due to its certification purposes. The emerging ISO 9001:2015 specification addressing People and Skills could be used to relate the organizational quality level to the learning and training level.

APPENDIX 2: List of reference Workplace Learning Ecosystems Samples
Standards and specs are useless until early pioneers dare first adoption to show their usability and advantages. This section is a living section intended to include Projects and/or Commercial Platforms and Systems, using at least a couple of the specifications listed in Table 12 coming from different Worlds and describing how they solved interoperability.

In order to list existing implementations and cases the LACE project has included a ‘vendors’ session to the LAW part of the Evidence Hub. All those willing to add evidence may do so by accessing the form available at [http://evidence.laceproject.eu/](http://evidence.laceproject.eu/) or by writing to the mail of the author of this Review ([f.cardinali@skillaware.com](mailto:f.cardinali@skillaware.com)).

The Skillaware™ Performance Support & Learning Analytics Solution

The Skillaware™ Platform ([www.skillaware.com](http://www.skillaware.com)) is a new software platform that combines the benefits of Electronic Performance Support, Business Process Improvement and Guidance and Online Learning & Knowledge Management, in order to help IT Departments to better engage, support and train their workforce and customers during the rollout and uptake of new business processes and software tools within their organizations. Skillaware™ uses new emerging interoperability standards in the area of Learning Analytics (e.g. Experience API from ADL), Business Process Management (e.g. BPMN 2.0 from OMG), Technical Documentation (e.g. DITA from OASIS) to support end user learning experiences during the on boarding of new procedures and platforms. The Skillaware platform is part of a larger ecosystem named O.S.A.™ developed by the sedApta Manufacturing IT Group and interoperating 3 different service oriented architectures using open standards and protocols to integrate the 3 Worlds of Business Process Orchestration, Support and Analytics (Figure.12)
The benefits and ROI of using an open standard-based infrastructure such as that depicted in O.S.A.™ have been effectively showcased during several implementation projects. For instance, O.S.A.™ was used for the roll out of new Warehouse and Supply Chain Management Systems within large Automotive Groups, new CRM and ERP platforms for Sales and Administration staff and for the support of call centre operators during decision taking and new product and services rollouts.

**The WatchMe Project**

The WatchMe project ([www.project-watchme.eu](http://www.project-watchme.eu)) aims to improve workplace-based feedback and assessment and professional development by means of learning analytics. It solves the efficiency and quality problems of workplace-based feedback and assessment by means of an electronic portfolio system, which is enhanced with: a) student models that monitor the learners’ competency development, b) a Just-in-Time feedback module, c) visualisation tools that inform learners, teachers and institutes just in time as well as on an analytical level. Impact: Quality and efficiency of workplace-based feedback and assessment will increase, as well as the development of professional expertise throughout the domains.

The project is a multidisciplinary collaboration between educational scientist and technologists with test beds in three professional fields throughout Europe. This will increase partnerships between professional education and technical industry. Furthermore, the WATCHME focus is on
trainees that perform their work from multiple locations. Considering that exchange among students is increasing in last years and that nowadays students are more flexible and mobile in different settings during education, the caption and monitoring of their progresses are extremely interesting, but also to use their data at an aggregated data demands a LA-based approach.

The TellMe Project

The TELL ME project (http://www.tellme-ip.eu/) aims to bring the latest technologies and methodology insights to manufacturers (esp. SMEs) to improve training and learning performance. Three concurrent evaluation methodologies have been adopted in the project: ECOGRAI, STEEP and Living Labs. ECOGRAI looks primarily at the micro-system level of the specific workplace, to engage the different stakeholders in an analysis of the workplace as a system, and then identify suitable Performance Indicators in relation to objectives as well as drivers – Decision or Action Variables – that can act on the system in order to reach those objectives. The monitoring of indicators thus not only reveals a state of play but also provides clues as to what steps should be taken to improve the current situation with respect to identified objectives. In addition, the resulting set of Performance Indicators is by definition more manageable and actionable.

In turn, STEEP takes a broad look at the societal dynamics shaping the workplace, from the ‘outside-in’ perspective. The acronym summarizes the five different dimensions that are considered as relevant: Social, Technological, Economic, Environmental and Political. Following this methodology, the major trends are identified for each dimension and Performance Indicators are identified for each trend. The basic idea here is that these are times of great uncertainty, and the micro-dynamics of a company need to be constantly related to issues such as globalisation, growing diversity and heterogeneity of employees, workplaces and personal living concepts: these are in fact the main drivers for the need for life-long learning. Finally, Living Labs effectively complete the TELL ME evaluation approach, by introducing and elaborating on the stakeholder dimension, seen across the various instantiations of individual and group behaviour aimed at creativity and innovation.

In this sense, it can be said that while the focus of ECOGRAI is set on the corporate dimension, trying to define the implications of stakeholders’ views on the definition of indicators of performance (and therefore innovation), and the major contribution of STEEP is to emphasize the weight of societal aspects (external to enterprise) on organisational
creativity and innovation, what is left to the Living Lab is the task to explore and assess the implications of ICT-supported stakeholder engagement (both inside and outside the borders of organisations) towards collective awareness, action and transformation. The way these multiple perspectives can be made operational requires an integrated evaluation approach, which comes as the original output of this round of analyses and reflections within the TELL ME team. The proposed approach complies with looking at the Job/Company/Business and Societal perspective as concentric worlds, each containing a number of instances of the other and thus bringing qualifications and specifications to the broad performance measurement aim.