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Information technology for learning, education and training — Learning analytics interoperability —

Part 1: Reference model

Technologies pour l'éducation, la formation et l'apprentissage — Interopérabilité de l'analytique de l'apprentissage — Partie 1: Modèle de référence

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 36, *Information technology for learning, education and training*.

A list of all parts in the ISO/IEC 20748 series, published under the general title *Information technology for learning, education and training — Learning analytics interoperability*, can be found on the ISO website.

Introduction

The increasing amount of data being generated from learning environments provides new opportunities to support learning, education and training (LET) in a number of new ways through learning analytics. Learning analytics is a composite concept built around the use of diverse sub-technologies, workflows and practices and applied to a wide range of different purposes. For instance, learning analytics is being used to collect, explore and analyse diverse types and interrelationships of data, such as: learner interaction data related to usage of digital resources; teaching and learning activity logs; learning outcomes and structured data about programmes; curriculum and associated competencies.

Learning analytics is an emerging technology addressing a diverse group of stakeholders and covering a wide range of applications. Learning analytics raises new interoperability challenges related to data sharing; privacy, trust and control of data; quality of service, etc. Through use case collection in the ad-hoc group on learning analytics interoperability, established under JTC1/SC36 in 2014, the following issues were identified and captured as general requirements for learning analytics applications:

For the learner:

— tracking learning activities and progression;

— tracking emotion, motivation and learning-readiness;

— early detection of learner's personal needs and preferences;

— improved feedback from analysing activities and assessments;

— early detection of learner non-performance (mobilizing remediation);

— personalized learning path and/or resources (recommendation).

For the teacher:

— tracking learners/group activities and progression;

— adaptive teacher response to observed learner's needs and behaviour;

— early detection of learner disengagement (mobilizing relevant support actions);

— increasing the range of activities that can be used for assessing performance;

— visualization of learning outcomes and activities for individuals and groups;

— providing evidence to help teacher improve the design of the learning experience and resources.

For the institution:

— tracking class/group activities and results;

— quality assurance monitoring;

— providing evidence to support the design of the learning environment;

— providing evidence to support improved retention strategies;

— support for course planning.

In addition, learning analytics practice can build upon prior work in LET standardization and innovation but there are several factors that require special attention. These factors include:

— requirements arising from the analytical process;

— data items required to drive operational LET systems are not always the same as desired for learning analytics;

— volume, velocity and variety of the data collected for analytics indicate different IT architectures, which imply different interoperability requirements;

— use of learner data for analytics introduces a range of ethical and other socio-cultural issues beyond those which arise from exchanging data between operational systems.

Therefore, this document gives a conceptual description of the behaviour of components related to learning analytics interoperability. In particular, this document specifies terms as well as proposes a reference model for the learning analytics process and interoperability.

Information technology for learning, education and training — Learning analytics interoperability —

Part 1: Reference model

1 Scope

This document specifies a reference model that identifies the diverse IT system requirements of learning analytics interoperability. The reference model identifies relevant terminology, user requirements, workflow and a reference architecture for learning analytics.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
accessibility
usability of a product, service, environment or facility by individuals with the widest range of capabilities

Note 1 to entry: Note 1 to entry: Although “accessibility” typically addresses users who have a disability, the concept is not limited to disability issues.

[SOURCE: ISO/IEC 24751-1:2008, 2.2]

3.2
assessment
means of measuring or evaluating learner understanding or competency

3.3
dashboard
user interface based on predetermined reports, indicators and data fields, upon which the end user can apply filters and graphical display methods to answer predetermined business questions and which is suited to regular use with minimal training

[SOURCE: ISO/TS 29585:2010, 3.3]

3.4
data analysis
systematic investigation of the data and their flow in a real or planned system

[SOURCE: ISO/IEC 2382:2015, 2122686]

3.5
data collection
process of bringing data together from one or more points for use in a computer

EXAMPLE EXAMPLE To collect transactions generated at branch offices by a data network for use at a computer centre.

[SOURCE: ISO/IEC 2382:2015, 2122166]

3.6
data exchange
storing, accessing, transferring, and archiving of data

[SOURCE: ISO 10303-1:1994, 3.2.15]

3.7
data flow
movement of data through the active parts of a data processing system in the course of the performance of specific work

[SOURCE: ISO/IEC 2382:2015, 2121825]

3.8
data format
arrangement of data in a file or stream

[SOURCE: ISO/IEEE 11073-10201:2004, 3.14]

3.9
data source
functional unit that provides data for transmission

[SOURCE: ISO/IEC 2382:2015, 2124348]

3.10
individual
human being, i.e. a natural person, who acts as a distinct indivisible entity or is considered as such

[SOURCE: ISO/IEC 24751-1:2008, 3.21]

3.11
learning analytics
measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs

3.12
learning platform
integrated set of (online) services that provide learner, teacher and/or others involved in learning, education and training with information, tools and resources to support and enhance educational delivery and management

3.13
learning outcome
what a person is expected to know, understand or be able to do at the end of a training programme, course or module

[SOURCE: ISO/IEC 17027:2014, 2.57]

3.14
usability
extent to which a product can be used by specified users to achieve specified goals, with effectiveness, efficiency and satisfaction, in a specified context of use

[SOURCE: ISO 9241-11:1998, 3.1]

3.15
workflow
depiction of the actual sequence of the operations or actions taken in a process

Note 1 to entry: Note 1 to entry: A workflow reflects the successive decisions and activities in the performance of a process.

[SOURCE: ISO 18308:2011, 3.52]

4 Abbreviated terms

ADL	advanced distributed learning
AFA	access-for-all
API	application programming interface
ICT	information and communication technologies
LET	learning, education and training
LMS	learning management system
LOD	linked and open data
PLE	personal learning environment
VLE	virtual learning environment
xAPI	experience API

5 Use cases and practices

5.1 General

Use cases were collected from national bodies and liaison organizations of ISO/IEC JTC1/SC36. The use cases illustrate key functionalities related to learning analytics by focusing on particular requirements that stakeholders may have and then outlining how such requirements can be reflected in workflows for learning analytics. A total of fifteen use cases were received in 2014.

Use cases considered four main areas:

— learning analytics;

— assessments;

— data flow and data exchange;

— accessibility preferences.

The summary of the use cases is presented in Clause 5. The complete list of use cases is available in Annex A.

5.2 Learning analytics

A stakeholder has previous experience with analytics dashboards available in online learning platforms (known as learning management systems (LMS) or virtual learning environments (VLE)). In general, data logs were not in a format that non-technical users could interpret, but these are now rendered (displayed) via a range of graphs, tables and other visualization forms, and custom reports designed for learners, educators, administrators and data analysts. Learners may get basic analytics from dashboards such as progress relative to the cohort average marks or engagement ratio.

Learning analytics are delivered with more advanced features, namely predictive analytics. Predictive analytics focuses on the pattern of learners' static data (e.g. demographics; past attainment) and dynamic data (e.g. pattern of online logins; quantity of discussion posts). Once a student's trajectory is drawn (e.g. "at risk"; "high achiever"; "social learner"), timely interventions can be planned (e.g. offering extra social and academic support; presenting more challenging tasks).

Learning analytics are used to enhance the personalized learning environment (PLE). Based on learning analytics output, the PLE can recommend learning pathways combined with learning content or resources. This service model enables fine-grained feedback (e.g. which concepts have been grasped and at what level), and adaptive presentation of content (e.g. not showing material that depends on the mastery of concepts that the learner is yet to acquire).

Other types of learning analytics are social network analytics and discourse analytics. Social network analysis makes visible the structures and dynamics of interpersonal networks to understand how people develop and maintain these relations (in the classroom or learning community). Discourse analytics requires the use of sophisticated technology to assess the quality of text in order to scaffold the higher-order thinking and writing skills that we seek to instil to learners.

5.3 Assessment

One of the advantages of using ICT in assessment is to improve precision in evaluating individual learning in order to provide input to (adaptive) learning systems. Learning analytics are useful for monitoring how students are going about learning and solving problems. This can be achieved by embedding learning assessments within the learning experience and analysing process data in log files that capture every click and keystroke. It is important to note that embedded assessments do not need to be hidden assessments. Feedback and recommendations from the analytics platform can be highly motivating, showing learners where they should focus their attention and learning efforts along with highlighting their accomplishments.

5.4 Data flow and data exchange

Increasingly, many institutions are requiring interoperable data formats and exchange mechanisms that simplify the process of collecting and delivering learning data to and from digital learning environments. This is being driven by the proliferation of heterogeneous data generated from learning systems and applications. The Experience API (xAPI, see https://www.adlnet.gov/adl-research/performance-tracking-analysis/experience-api) and Caliper Analytics (Caliper, see http://www.imsglobal.org/activity/caliperram) are identified as potential standards applicable to stakeholders. The implication from xAPI and Caliper in terms of interoperability standards is that it is necessary to standardize profiles for presenting learning data as well as APIs implementing data capture.

One of the most important things in learning analytics is data control by the individual of his or her personal information (e.g., as a learner), including options such as "do not track" or "data chrono-

degradability". One of the cases describes an approach to giving the learner (or his/her parents) control over the data of that individual as a learner in a school setting. The use case follows the learner from registering at a school, to moving to another school, with interactions with the school (and through the school with suppliers of services, e.g., publishers). Other important issues with data control are privacy and identification of people through identity federation. Most use cases have similar privacy issues and this implies the privacy requirements and related technology should be a fundamental component of any learning analytics. Applying privacy requirements such as anonymization and pseudonymization should be reflected into learning analytics.

Learner activity data may be generated from a wide variety of platforms, including but not limited to web-based applications, desktop computers, mobile devices, wearable technologies and the internet of things. These tracking data may be used in portfolio services. As described in 5.2, diverse types of learning data can be reflected for each learner's learning activity and progress. The portfolio service is not limited to curating and showcasing learner's output, but also to diagnosis of strengths or weaknesses in learning contexts. Many portfolio services focus on the display of learner content and self-reflection by leaners. However, improved portfolio services, based on learning analytics, will show multidimensional perspectives of learner performance and activity data.

5.5 Accessibility preferences

Dashboards provide a general way to present analytics information. This category of use cases describes how a dashboard should be presented flexibly and filtered by purposes. One of the use cases introduces scenarios for users (e.g. learner, teacher and module manager) with accessibility needs and preferences. Learning analytics enables teachers or administrators to deliver effective learning with accessibility needs being met, supported by data generated from the learning analytics. An example is supporting the needs of a learner with a vision-impairment through resources that have proven to be highly effective with learners with similar needs.

Another scenario related to accessibility is focused on early detection via learning analytics, supporting diagnostic testing for impairments, such as visual or hearing impairments, auditory processing disorder (APD), dyscalculia or dyspraxia; and provide remediation or support. Accessibility preferences may be stored in the cloud to deliver seamless service across diverse devices.

6 Reference model for learning analytics interoperability

6.1 General

In Clause 6, a preliminary reference model for learning analytics is introduced by detailing the set of processes and relationships between them that is formulated from the collected use cases provided in Annex A.

A workflow of general data analytics is presented in 6.2. The general data analytics workflow is extended and transformed into a loop by adding teaching and learning activities to the workflow as noted in 6.3. Additional details regarding the key elements of the reference architecture are provided in the sub-clauses of 6.3.

6.2 Workflow for general data analytics

The goal of learning analytics is to understand and improve learning and its environment and encompasses the tasks of measurement, collection, analysis and reporting of data about learners and the learning, education and training (LET) contexts in which learning occurs. These tasks closely match the workflow of data analytics as shown in Figure 1. Such correspondence is not coincidental but suggests that learning analytics can take advantage of the technological advancement of data analytics in building a learning analytics framework.

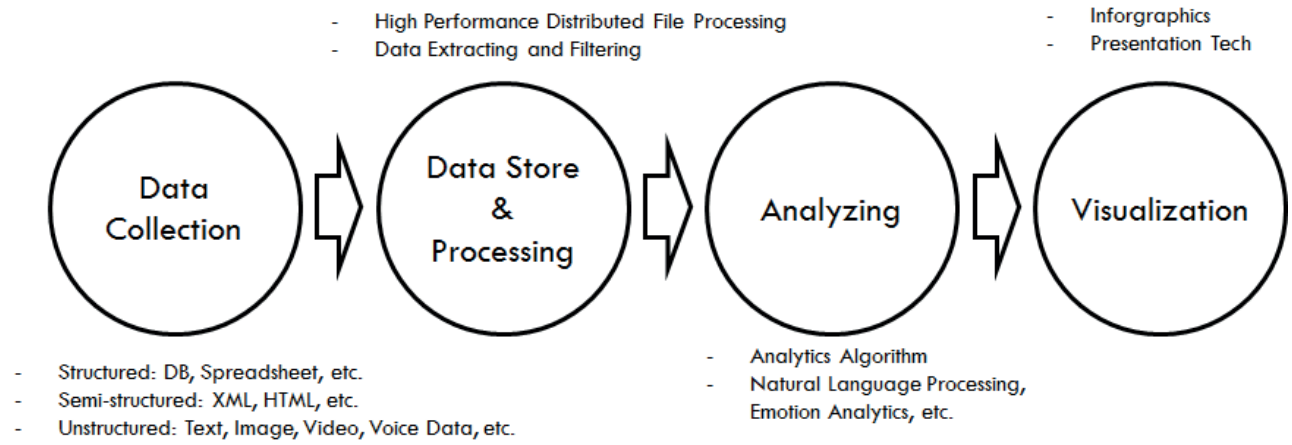

Figure 1 — Workflows for general data analytics

6.3 Reference architecture derived from workflow and use cases

6.3.1 General

There are a total of six processes in the learning analytics workflow that are supported by privacy and data protection requirements, as noted in Figure 2. Although learning analytics is primarily based on data collection and analysis, learning and teaching activities within LET contexts are fundamental to the whole process and need to be considered in order for a feedback loop to be enabled. Learning and teaching activities provide sources for data collection and subsequent processes of the learning analytics workflow.

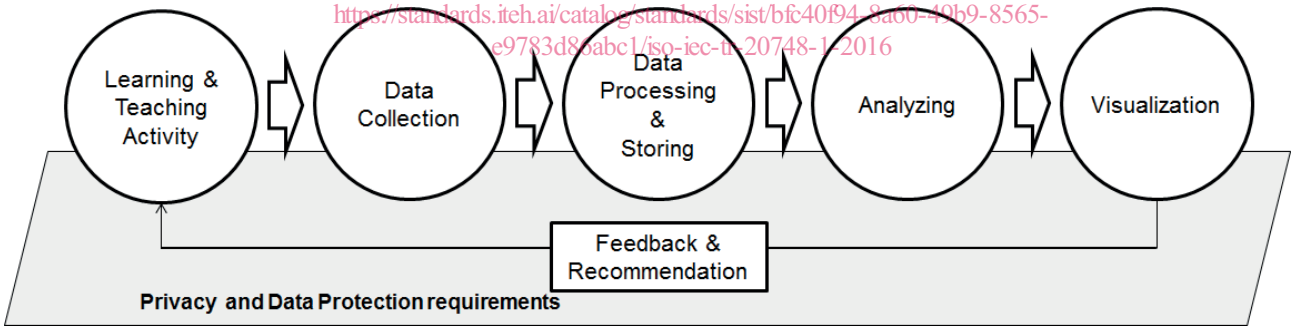

Figure 2 — Abstract workflow of learning analytics

The six processes that comprise the learning analytics workflow (Figure 2) are:

— ***Learning and teaching activity***: data modelling sources of learning activities in order to decide upon learning activity data that could be used for analytics, and the release of learning activity data for data collection.

— ***Data collection***: gathering andhttps://en.wikipedia.org/wiki/Measuringmeasuring information on variables of interest in the learning and teaching activities.

— ***Data processing and storing***: preparing and storing data from diverse and heterogeneous data sources for interoperable data analysis by utilizing the standardized data model and representation.

— ***Analysing***: systematic investigation of learning data by inspecting and modelling the learning data with the goal of producing descriptive and possibly predictive knowledge.