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

Part 2: System requirements

*Technologies de l'information — Éducation, formation
et apprentissage — Interopérabilité de l'analytique de
l'apprentissage —*

Partie 2: Exigences relatives au système



Reference number
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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	3
5 Issues and concerns	3
5.1 General	3
5.2 Accessibility	4
5.3 Interoperability	4
5.4 Privacy	5
5.5 Identity federation	5
5.6 Data life cycle	5
6 System requirements	5
6.1 General	5
6.2 Privacy policy	6
6.3 Data protection	7
6.4 Learning and teaching activity	8
6.5 Data collection	8
6.5.1 General	8
6.5.2 Accessibility	8
6.5.3 Aggregation/integration of data	8
6.5.4 Data interoperability	9
6.5.5 Data flow and exchange	9
6.6 Data processing and storing	9
6.6.1 General	9
6.6.2 Data storing	9
6.6.3 Data translating/filtering	10
6.7 Analysing	10
6.7.1 General	10
6.7.2 Privacy	10
6.7.3 Analysis interface	10
6.7.4 Scalability for data input	10
6.8 Visualization	11
6.8.1 General	11
6.8.2 Accessibility	11
6.8.3 Privacy	11
6.8.4 Data interface	11
6.9 Feedback actions	11
6.9.1 General	11
6.9.2 Analysis query interface	12
6.9.3 Data interpretation and response	12
Bibliography	13

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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 ISO documents 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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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 36, *Information technology for learning, education and training*.

A list of all parts in the ISO/IEC 20748 series can be found on the ISO website.

This corrected version of ISO/IEC TR 20748-2:2017 incorporates the following corrections:

- headers have been corrected and now read “ISO/IEC TR” instead of “ISO/TR”.

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 and 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. The following issues are identified as general requirements for learning analytics applications:

For the learner:

- tracking learning activities and progression;
- tracking emotion, motivation and learning-readiness;
- early detection of the 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 teachers 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;
- the 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.

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

Part 2: System requirements

1 Scope

This document specifies system requirements for learning analytics systems and services. Learning analytics systems and services are assumed to be composed of independent processes and applications having diverse purposes. To improve efficiency for communication and operation between systems and/or services, the system requirements identify each system's role, capability and recommended performance, etc. The system requirements are based on ISO/IEC TR 20748-1 and additional use cases came from the National Bodies and Liaison Organizations (NBLOs).

2 Normative references

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: 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

[SOURCE: ISO/IEC TR 20748-1:2016, 3.2]

3.3

curriculum

standard that refers to learning outcomes aligned to specific topics or units of learning

**3.4
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]

**3.5
data analysis**

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

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

**3.6
data collection**

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

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

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

**3.7
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 source**

functional unit that provides data for transmission

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

**3.9
data storage**

means for storing information from which data is submitted for delivery, or into which data is put by the delivery authority

[SOURCE: ISO/IEC 13888-1:2009, 3.7]

**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, 2.20]

**3.11
interoperability**

capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units

[SOURCE: ISO/TS 19101-2:2008, 4.17]

**3.12
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

[SOURCE: ISO/IEC TR 20748-1:2016, 3.11]

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**workflow**

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

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

API	application programming interface
LET	learning, education, and training
LMS	learning management system
LRS	learning record store
LTi	learning tools interoperability
SSO	single sign-on
VLE	virtual learning environment

5 Issues and concerns**5.1 General**

In use cases of ISO/IEC TR 20748-1 and additional comments from NBLOs, there are some of issues and concerns related to data used for learning. For learning analytics interoperability, data gathered, analysed and visualized need to comply with stakeholders' requirements and concerns listed in this document. As shown in [Figure 1](#), stakeholders expect several features within data flows, such as accessibility, data interoperability, privacy protection, interpretation for data, etc. Prior to defining specific system requirements for learning analytics, this clause identifies general issues and concerns for learning analytics

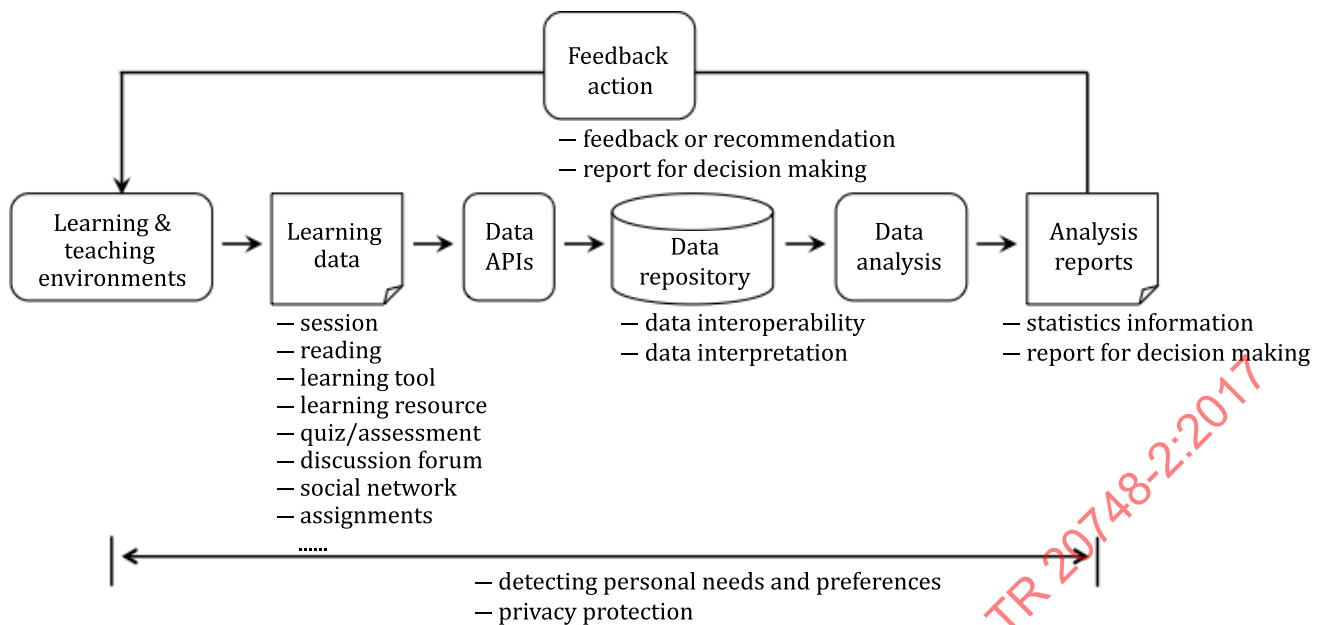


Figure 1 — Data flows and requirements

5.2 Accessibility

Adaptive technologies supporting individual accessibility are now well-integrated into operating systems and tools. This means that a single resource may be accessed and used in different ways. For example, a text reading activity could be turned into a listening activity when text to speech function is activated by, for example, a visually impaired learner. Inversely, a video demonstration could be partly turned into a reading activity when subtitles are used by a hearing-impaired learner or a non-native speaker. In addition, personal needs and preferences can be used to activate features such as automatic translation or modifying the page layout used for eye tracking. These parameters should be captured in context statements sent to the learning record store (LRS).

At the time of providing insights and feedback, learning analytics solutions often rely on an extensive use of visual feedback based on dashboards with traffic lights, graphs and other visual representations. It is important that alternative displays be made available for colour-blind people and visually impaired users. These may include different rendering modes to convey feedback and recommendation, such as displaying ranks, tables or percentages.

5.3 Interoperability

A growing number of learning interactions take place in a web-based environment. For example, learning management system (LMS) or virtual learning environment (VLE) can provide content, forums, assessment, access to third party learning softwares and digital textbooks. Learning analytics rely on a large variety of data tracking sources that may range from educational administration software to sensors. Collected data may be formatted using proprietary format or standardized formats such as Caliper and xAPI. To ensure proper data flow, exchange and analysis, provision for interoperability should be included at all levels including:

- academic information systems providing information on student enrolment, grades, needs and preferences;
- LMS or VLE tracking usage such as log-in/out timestamps, access to content resource, assessment results and content;
- geolocalization data;

- third parties' service and software such as the use of cloud storage, reading application for digital textbook or simulation;
- technical information including device identification and network information (type of connection, connection speed);
- specialized devices such as electroencephalography (EEG), eye tracking systems, video input for emotional analysis and biometric sensors.

5.4 Privacy

Compliance with privacy protection requirements is required by various laws and regulations. These also apply to the ITLET environment and especially in the field of learning analytics. The privacy protection requirements from a "systems" perspective will be stated in the upcoming Part 4 of ISO/IEC 20748. A list of privacy principles appears in ISO/IEC 29100.

5.5 Identity federation

Since data collection generally occurs from heterogeneous tools and services, consistent user identification needs to be applied to ensure seamless data flow and to protect privacy. Student identification should be properly registered and maintained throughout the whole processes of learning analytics.

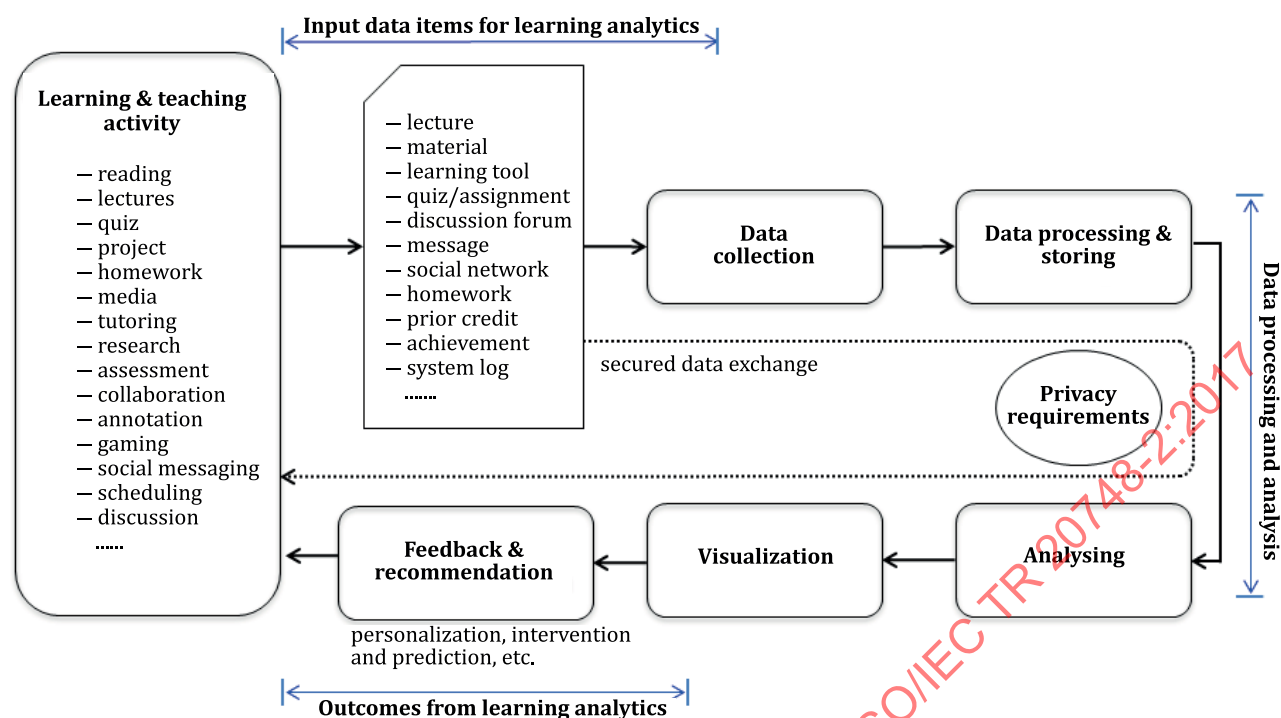
5.6 Data life cycle

Raw data should not be stored longer than necessary for achieving the aims of the particular LA session. In case of longitudinal analysis, the data should be re-identified. However, in the event of withdrawal of consent from the tutor or the learner for data collection or processing, provisions should be made for immediate data deletion and/or other appropriate actions.

6 System requirements

6.1 General

This document specifies system requirements composed of several processes, functions and system interfaces. In this clause, specific guidelines to implement the reference model of learning analytics along with the seven major components of learning analytics as identified in ISO/IEC TR 20748-1. The six major components include five steps for the workflow of learning analytics and one component for privacy policy as shown in [Figure 2](#). The six steps consisting of data creation, collection, processing, analysing, visualization and feedback are mainly involved with requirement for their functions and interfaces.



NOTE Source: ISO/IEC TR 20748-1.

Figure 2 — Reference workflow of learning analytics

6.2 Privacy policy

Issues related to privacy and data protection should be addressed both in design and application of learning analytics systems. A privacy policy should be established prior to system development as privacy and data protection requirements should inform the design of the whole workflow of the system and services

NOTE ISO/IEC 29100 defines privacy policy as "overall intention and direction, rules and commitment, as formally expressed by the personally identifiable information (PII) controller related to the processing of PII in a particular setting". As described in ISO/IEC 29100, the term "privacy policy" is often used to refer to both internal and external privacy policies.

Requirement ID	Description
R1.1.1	ISO/IEC 29100 specifies general requirements for establishing and communicating a privacy policy that is appropriate to the purpose of the organization, provides framework for setting objectives, includes a commitment to satisfy applicable privacy safeguarding requirements, and include commitment to continual improvement. In a learning analytics context, the PII principals (e.g. learners, teachers, support staff) may do their privacy risk assessment related to pedagogical objectives, social or cultural aspects of participating in learning communities, etc. Therefore, a privacy policy should also address issues as: — Who owns the data related to learning activities? — How is the data flow between different stakeholders, and are data shared with third parties? — What are the specific privacy safeguarding requirements related to activity data collected from different learning environments the organization provides? All privacy-related policies, procedures and practices should be documented and communicated as appropriate (see also ISO/IEC 29100:2011, 5.10). <i>(ISO/IEC 29100 defines PII principal: natural person to whom the personally identifiable information (PII) relates; privacy risk assessment: overall process of risk identification, risk analysis and risk evaluation with regard to the processing of personally identifiable information (PII); privacy safeguarding requirements: set of requirements an organization has to take into account when processing personally identifiable information (PII) with respect to the privacy protection of PII)</i>
R1.1.2	Whether data can be allowed to be collected and shared between systems should be controlled by the user on the learning analytics system/service.

6.3 Data protection

Data protection regulations differ across jurisdictions. The right to the protection of personal data is not an absolute right; it should be considered in relation to its function in society and be balanced against other fundamental rights. In most legal frameworks, this principle is expressed in requirements for purpose specification (collection only for specified, explicit and legitimate purposes), and compatible use (e.g. further processing should not be incompatible with the purposes for which personal data were collected).

Requirement ID	Description
R2.1	Learning analytics systems and practices should comply with the data protection laws in the particular jurisdiction they are used. However, for learning analytics services to work as intended, this document will stress the need to build trust in online environments used for learning. Transparency, predictability and user control will contribute to trust in learning analytics systems. Consent of the learner to the processing of their personal data should be given by means of clear affirmative actions. Organizations should also promote data portability, i.e. giving learners easy access to one's own personal data and the freedom to transfer personal data from one service provider to another. Educational organizations should also consider how the learners could be given the right to be forgotten (e.g. when personal data are no longer necessary in relation to the purposes for which they were collected or otherwise processed) — to help people better manage data protection risks online. Principles of data protection do not apply to anonymous information, namely information, which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is no longer identifiable. However, re-identification is a threat when datasets are merged. Therefore, anonymization approaches within a learning analytics context should always be balanced with other measures to build trust and data protection.

6.4 Learning and teaching activity

Learning activities are the starting point of learning analytics and the source for data collection. In general, learning activities are performed on diverse environments and tools and thus, it is required that learning activity data is explicitly modelled or profiled so that data about diverse activities can be stored and processed in an interoperable way in the subsequent steps.

Requirement ID	Description
R3.1	The learning activity data can be explicitly modelled or profiled to handle diverse learning environments and tools while maintaining the capability to support specialized learning for individual institutions. EXAMPLE xAPI recipes and IMS Caliper Metric Profiles are examples of learning activity data models promoting interoperability.

6.5 Data collection

6.5.1 General

Data collection is the process of measuring and gathering information on matters of interest from learning and teaching activities. Tracking data from learners emanate from a wide variety of platforms, e.g. when accessing learning material, using desktop computers and mobile devices, including wearable technologies and the Internet of things. In this process, the requirements related to the data authority, control of data source, interoperability of data and efficient flow and exchange of data are addressed.

6.5.2 Accessibility

Requirement ID	Description
R4.1.1	Accessibility requirements should be registered prior to data collection.

6.5.3 Aggregation/integration of data

Requirement ID	Description
R4.2	To access heterogeneous learning systems or tools, aggregated profiles for the user should be supported.

6.5.4 Data interoperability

Requirement ID	Description
R4.3.1	To improve accuracy of collected data, standardized information models and controlled vocabularies should be applied to data collection API. EXAMPLE 1 Recipe for an xAPI specification is an example to define activity stream type and vocabularies. EXAMPLE 2 IMS Caliper Metric Profile is an example to define learning activity types and vocabularies.
R4.3.2	Data information model should cover a wide range of data types. EXAMPLE xAPI is an example to define statements and IMS Caliper is an example for metric profiles in terms of information model.
R4.3.3	Data information model should not be dependent on dominant products or services. NOTE xAPI and IMS Caliper are good examples for open specification about information model. Institutions can use both specifications to develop its profile in terms of specific purpose or customization.
R4.3.4	Collected data can be validated for conformance prior to storage. NOTE Conformance testing process is an optional requirement when learning activity data is being stored.
R4.3.5	Data interoperability should have the capability for semantic matching. NOTE 1 Semantic matching means to identify the same meaning between different words within captured data. NOTE 2 If the institution adopts more than one specification or profile for data capturing purpose, it is necessary to prepare semantic matching capability.

6.5.5 Data flow and exchange

Requirement ID	Description
R4.4.1	Collected data should be transmitted efficiently by eliminating redundant data or null records as needed.
R4.4.2	Data provenance should be maintained when data from different data sources are combined or exchanged.
R4.4.3	Collected data should be transmitted in secured ways.

6.6 Data processing and storing

6.6.1 General

Data storing and processing is the process of preparing and storing data from diverse and heterogeneous data sources for data analysis by utilizing the standardized data model and representation.

6.6.2 Data storing

Requirement ID	Description
R5.1.1	Temporary storage of collected data should be supported. NOTE 1 The type of data storage is not a recommendation. NOTE 2 Data in a temporary storage may be continuously updated.
R5.1.2	Data should be stored both before and after data translation and/or filtering. NOTE See 6.6.3

6.6.3 Data translating/filtering

Requirement ID	Description
R5.2.1	Between temporary data storage and data translating/filtering process, a data query interface should be supported.
R5.2.2	To filter and/or translate collected data, a unified form of data for storage can be used. NOTE 1 Filtered or translated data can be called data set for analysis. NOTE 2 Data set for analysis needs to keep static status if it is not inflicted.
R5.2.3	Once data translating/filtering is done, a migration interface can be used to proceed to storage.

6.7 Analysing

6.7.1 General

Analysing is the process of systematic investigation of learning data by inspecting, and modelling the learning data with the goal of producing descriptive, prescriptive and predictive knowledge.

6.7.2 Privacy

Requirement ID	Description
R6.1.1	Prior to starting data analysis, user identification should be pseudonymized or anonymized accordingly for the purpose of analysis. NOTE This requirement is dependent on the privacy policy (R1.1).

6.7.3 Analysis interface

Requirement ID	Description
R6.2.1	In analysis process, design for analysis models can be modularized. NOTE Modularization involves explicit specifications of input/output and functionality of components.
R6.2.2	In analysis process, visualization should be supported to generate output data set for export capability. NOTE If the result data from data analysis is periodical or time series data, it may be more effective to backup separately, because the output data set will be changed whenever the data analysis process is performed.

6.7.4 Scalability for data input

Requirement ID	Description
R6.3.1	To analyse learning activity data, at least one or more collected data set should be prepared.
R6.3.2	If the analysis process can generate personalized learning pathways or recommendations for learning resources, connection with third party repositories can be supported. NOTE General domain data, such as curricula and/or competencies, learning resources and preferences, can be used as references for advanced analysis.