
Information technology — Learning, education and training — Virtual experiment framework

*Technologies de l'information — Apprentissage, éducation et
formation — Cadre d'expérience virtuel*

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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 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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

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

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Introduction

New and emerging technologies are allowing learners to test and develop new knowledge for the creation of virtual experiments. By employing a collection of different technologies, virtual experiments are widely used within K-12 and higher education institutions (e.g. scientific laboratory experiments, technical training in medicine and biomedicine) and also within corporate training (e.g. flight simulators, manufacturing process control). Virtual experiments allow access to a wide range of different experiments, decrease the timeframe to complete experiments, eliminate hazardous situations, and reduce the costs of materials.

To facilitate the development of virtual experiment technology and specification integration, this Technical Report defines a virtual experiment framework that indicates how various standards and specifications can be combined to support the design, implementation, analysis and evaluation of virtual experiment systems. This Technical Report denotes the components and categories of related standards and specifications that can be used to support virtual experiment systems and learners. It illustrates how the components and categories can be structured to support implementations to improve reusability, reduce costs, and broaden applicability. It defines the framework of related virtual experiment standards and determines the mutual relations between different standards for designing, analysing and comparing different virtual experiment systems in order to promote the design and application of the virtual experimental components and systems. The framework of virtual experiment standards also helps to illustrate the categories of related virtual experiment systems and their relations in order to guide the development of other standard-setting work and normatively describe virtual experiment system.

Virtual experiments are typically accessed from an IT system, such as a learning management system (LMS), which provides the environment for learning. In addition to tools specifically tailored for learning, IT systems (such as LMSs) can also provide access to external tools. In a common scenario, an identity federation mechanism will automatically log into the external service but it is up to the learner whether to provide data inputs to the external tool. At the end of the activity, a score is returned to the IT system (e.g. LMS). This type of approach can be used to support activities, such as those involved in the scientific experimental approach, where there are requirements to repeat an experiment with a variety of parameters in order to assess their individual role in a process. There is a need to bridge the switch from the IT system (e.g. LMS) to an external virtual experiment tool, providing data inputs and recording outputs for further analysis. This Technical Report can be used to support these types of activities. In addition, this Technical Report provides specific considerations for the development of ITLET supportive technology and specification integration.

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Information technology — Learning, education and training — Virtual experiment framework

1 Scope

This Technical Report defines the framework for IT standards and specifications on virtual experiments supporting IT-enhanced learning, education and training. It is based on implementations of standards and specifications that are used to support virtual experiment, development, evaluation and management that rely on ITLET.

This Technical Report

- provides a framework that can be used for virtual experiment systems that rely on ITLET,
- determines the categories of different virtual experiment standards and specifications and their relationships to facilitate their integration,
- promotes the appropriate design and application of virtual experiment components so that IT systems that are being used are reusable, low cost, and more broadly applicable,
- indicates considerations to be taken into account when developing ITLET systems that are being developed or used to support virtual experiment systems,
- provides sample architecture of a virtual experiment system framework that can be used to support further development of virtual experiments,
- illustrates various roles that different actors can have at various points within the virtual experiment system,
- demonstrates how standards and specifications that support virtual experiments can be combined to form the basis for future work and implementations.

The following aspects are not addressed in this Technical Report:

- specifications of the implementation details of virtual experiment systems;
- accessibility;
- privacy;
- security.

2 Conformance

It is noted that it is possible for a virtual experimental instruction system to support more than one standard or specification by utilizing different combinations that include base standards, specifications, etc. The standards or specifications coordinate with circumstances or the virtual experiment instruction system that is configured separately to support specific standard or specification combinations.

This Technical Report provides the framework and objective to assist in the development of virtual experiments for information technology supporting learning, education, and training. This Technical Report also provides a proposed architecture of a system framework that is used to support the further development of virtual experiments. This Technical Report provides specific considerations for the development of ITLET supportive technology and for the integration of IT standards and specifications.

3 Terms and definitions

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

- 3.1 component cartridge**
assembly of all the junior units based on specific rules to form a bigger component cell
- 3.2 remote access laboratory**
laboratory in the physical world which can be accessed remotely
- Note 1 to entry: Access to simulated equipment and virtual laboratories are excluded.
- Note 2 to entry: A remote access laboratory enables learners to perform experiments at their own pace, time and location and allows teaching staff and learners to access laboratory facilities beyond their institutions.
- 3.3 virtual experiment**
experiment based on multimedia, simulation and *virtual reality* (3.6), etc. which can assist or replace the operating segments of traditional, face-to-face experiments
- 3.4 virtual experiment component**
smallest unit in a *virtual experiment* (3.3) which is composed of controllable and operable virtual experiment objects that may be reused
- 3.5 virtual laboratory**
open networked instructional system based on web and *virtual reality* (3.6) technologies, which consists of virtual benches
- 3.6 virtual reality**
artificial environment presented in the computer

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4 Symbols and abbreviated terms

CP	Content Packaging
CC	Common Cartridge
LOM	Learning Object Metadata
LIS	Learning Information System
LMS	Learning Management System
MLR	Metadata for Learning Resources
QTI	Question and Test Interoperability
SCORM	Sharable Course Object Reference Model
SOA	Service-Oriented Architecture
XML	Extensible Markup Language

5 Framework

5.1 General

The framework for IT standards and specifications on virtual experiments supports IT-enhanced learning, education and training. For assistance with the development of profiles, the related standards and specifications for virtual experiment instruction is shown in [Figure 1](#).

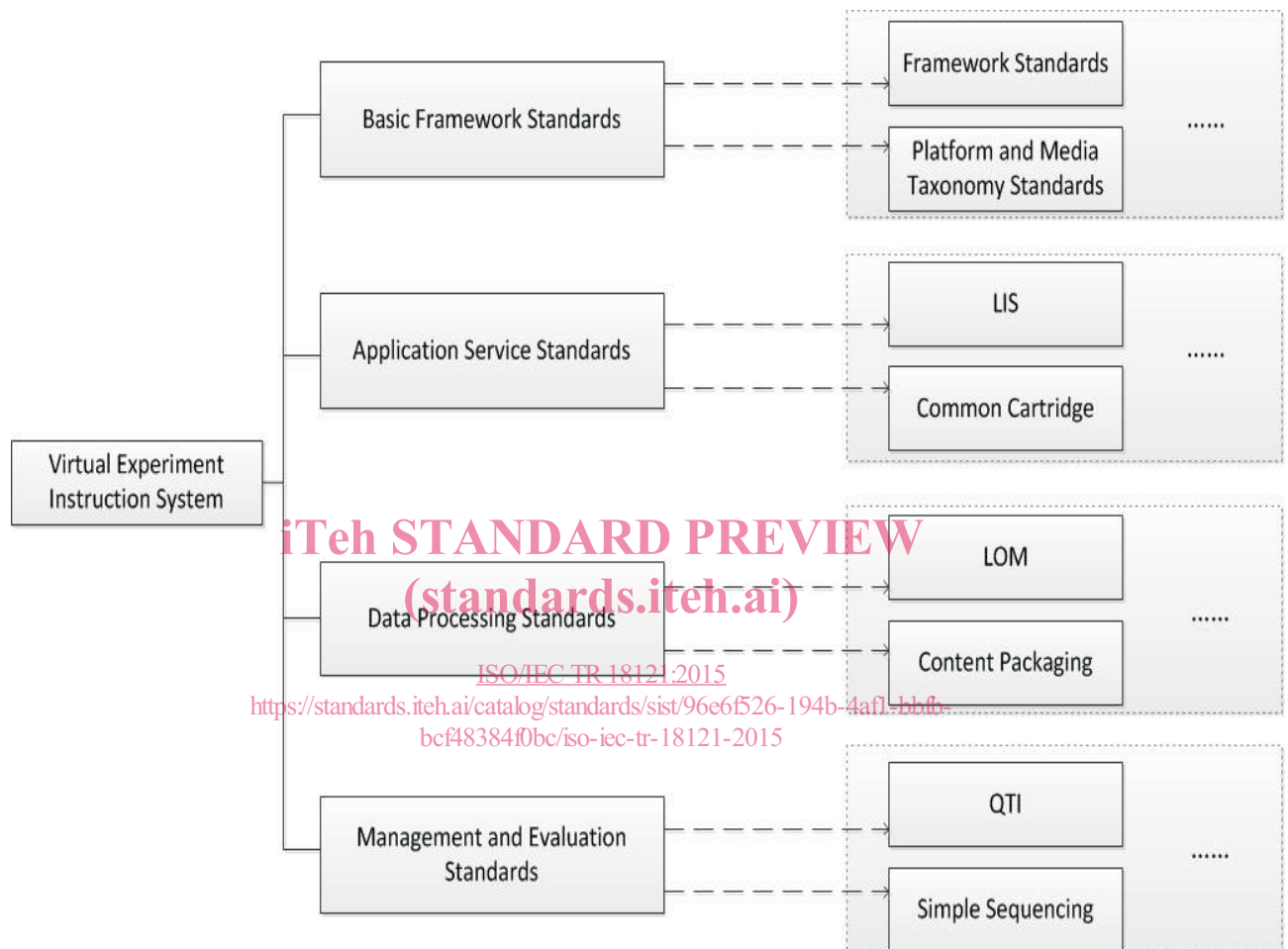


Figure 1 — Related standards of a virtual experiment instruction system

The virtual experiment standard system establishes the whole virtual experiment standards framework system and identifies the various links to standards of the virtual experiment instruction. The virtual experiment standards system also defines the relationship of standards and specifications and combines them with each other properly.

5.1.1 Overview of virtual experiment framework

The virtual experiment framework standard consists of the following four major parts.

— Basic framework standards and specifications

Basic framework standards focus on various compatible specifications of the virtual experiment platform and tools. They are the basis of the whole virtual experiment standard system.

— Application service standards and specifications

Application service standards focus on the normative description of service interface provided by virtual experiment teaching systems which can help to improve the management of services.

— Data processing standards and specifications

Data processing standards are the hard core of the whole virtual experiment standard system, providing data elements of virtual experiment component metadata and a conceptual data mode, which are used to define an instance of metadata structure.

— Management and evaluation standards and specifications

Management and evaluation standards concentrate on how to control and manage the virtual experiment procedures in a standardized way for the purpose of helping learner complete the experiment in the experimental processes.

5.1.2 Core feature of virtual experiment framework

The virtual experiment framework mainly illustrates the categories of related virtual experiment standards and describes the relations among the standards in order to promote the virtual experiment resources-sharing and interoperability of virtual experiment systems.

5.1.3 Basic specifications

The virtual experiment framework is established on some related specification such as CP, CC, SCORM, etc. All the specifications are described in detail in their own documents.

5.1.4 Relationship

The examples below provide the standard structure of a typical virtual experiment instruction system which normatively describes the standardized environment of the virtual experiment instruction system.

As shown in [Figure 1](#), this virtual experiment instruction system conforms to some related virtual experiment standards which are divided into four categories: basic framework standards, application service standards, data processing standards, and management and evaluation standards. The specific explanations of virtual experiment instruction system are provided below.

— Basic framework standards and specifications

The virtual experiment instruction system may conform to the virtual experiment terminology specification to regulate the definition of key terms and the explanation of symbols which are used in the system. The system unify the terms in the development process and help users to translate and use the standard correctly; meanwhile, it may also be beneficial to manage the virtual experiments system. Basic framework standards are in reference to framework standards (ISO/IEC/TR 24725-1:2011), platform and media taxonomy standards (ISO/IEC/TR 24725-3:2010), which help to manage the platform effectively and efficiently.

— Application service standards and specifications

In the process of virtual experiment instruction, the system has interoperability between different platforms. LIS is the definition of how to realize the exchange of information related to learning domains. Interoperability is best defined through the use of a domain profile. Common Cartridge is another successful example to establish a standardized way to package course so as to export and import content quickly and easily in learning management system. To some extent, the application service standards of virtual experiment are established on the basis of these two standards. However, it has its unique characters according to actual needs. Personal information and operation procedure, such as saving, resetting, configuring, are all recorded in the application service programs which can provide personalized service. Simultaneously, real-time feedback is offered to encourage correct operation or revise errors timely in the course of the experiment.

— Data processing standards and specifications

While using the virtual experiment instruction system, the data processing is a core part. The example of virtual experiment instruction system conforms to component description specification and component packaging specification. The function of component description specification is similar to LOM and includes exclusive environmental elements of virtual experiment beyond LOM; additionally, it helps to describe and classify the components of virtual experiments of the system normatively to promote the interchange and sharing of virtual experiment resources. The content packaging specification can be a method to assist packaging the components of multi-domain modelling standardized and define detailed interface to facilitate the retrieval and management for learners and instructors in the future.

— Management and evaluation standards and specifications

The virtual experiment instruction system also conforms to the procedure of management specification and the evaluation of test specification, which helps to standardize the procedure controlling and management of virtual experiment on the purpose of helping learners complete the experiment in learning process, tracking the learners' behaviour and providing accurate feedback. QTI specification and Simple Sequencing Specification can offer the references to deal with procedure, evaluation, and feedback.

5.2 Basic framework standards

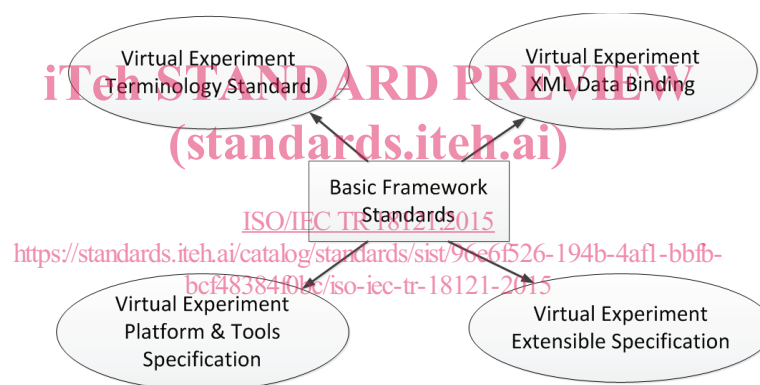


Figure 2 — Basic framework standards

Basic framework standards include virtual experiment terminology standard, virtual experiment Extensible Markup Language (XML) data binding, virtual experiment platform and tools specification and virtual experiment extensible specification as shown in [Figure 2](#).

Virtual experiment platform and tool specification focuses on various compatible specifications of the virtual experiment platform and tools. Virtual experiment extensible specification studies the extensible rules and implementation method aiming at the development process of virtual resources and experiments. Virtual experiment terminology standard provides the definition of key terms and the explanation of symbols which are used in virtual experiment standard system to unify the terms in the development process and help users translate and use the standard correctly. Virtual experiment XML data binding uses the common rules of the data format of XML binding for the processing of data streams and the integration of the system.