Technical specification prototype to foster interoperability between validation system and OER

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1. Introduction

The validation system for informal and non-formal learning (VINFL) has a central role in fostering mobility in Europe, ensuring transparency and comparability of qualifications. The adoption of learning paradigms based on competence oriented education has also contributed in supporting this scenario.

From a technical point of view, the development of these approaches is mainly hindered by the lack of technical specifications aimed at supporting interoperability between the online systems used in educational contexts. As a consequence, Learning Management System, (used to deliver courses) e-Portfolio systems, (used to store data related to the students' portfolio), and validation systems (used to validate the competence acquired by students during a course) are not integrated, making difficult to share information between them. Moreover, the lack of such a standard makes also difficult to define a common language to describe qualification levels, units and learning outcomes. This is particularly relevant in the VET sector, thus increasing difficulties in creating and sharing description for learning outcomes.

This report describes the activities undertaken in the framework of the IMPACT project to propose a strategy aimed at overcoming the limits presented above. In particular, the ECVET recommendation [5] was precisely analysed in order to develop a technical specification, implemented through an XML schema. The technical specification supports the interoperability between e-learning systems. In the IMPACT project a prototypical architecture - composed by Mahara to manage e-portfolio, Moodle as a LMS, and the LEVEL5 software as a validation system - has been also designed and tested.

1.1. Challenges

The development of an ECVET technical specification is a challenging task, in fact, as reported by the desk research undertaken in the (O1), the ECVET recommendation was adopted in different ways.

The intensive desk research conducted as a preliminary step before the IMPACT project highlighted two main findings:

1. The specifications in human language vary to a large extent in structures, quantity and quality. Hence a minimum standard specification (like the one established in 20051) has to be created in order to ensure interoperability.
2. By 2013/2014 only one technical specification for ECVET could be identified (eCOTOOL -project: 504614 - LLP - 1 - 2009 - DE - Leonardo - LMP). However, this project does not fit the needs, see further information at http://www.competencetools.eu/

For these reasons, a standardised technical specification is needed to allow:

- The implementation of proper functionalities in e-learning systems (each component of an e-learning eco-system has to work properly adopting a specific data structure in order to describe learning outcome (LO), or knowledge skills and attitudes)
- The interoperability between e-learning systems (validation system, LMS and e-Portfolio have to work as an ecosystem sharing a common data layer).
- The exchange of data (once the common data layer is defined, it is necessary to establish the appropriate transport layer)

1 EUROPÄISCHES LEISTUNGSPUNKTESYSTEM FÜR DIE BERUFSBILDUNG (EUROPEAN CREDIT TRANSFER SYSTEM FOR VET – ECVET) TECHNISCHE SPEZIFIKATIONEN, BERICHT DER TECHNISCHEN ARBEITSGRUPPE, 2005

1.2. Background and Motivation

In the VET sector the validation of learning outcomes and the related systems are designed along qualifications, units, learning outcomes (LO) and referring to the EQF or NQF systems that describe qualification levels in terms of knowledge, skills and competences (KSC). More than 100 pilot projects have been listed with their outcomes in http://www.ecvet-projects.eu, http://ecvet-toolkit.eu and http://ecvet-info.de portals, clustered in different sectors. In these project "competence matrices" or "qualification catalogues" for different professions have been developed and specific elements such as qualifications, units, LO, KSC have been described and valued against ECVET levels and connected to credit points. However, a basic technical specification for the description of qualifications, units and learning outcomes as outlined in the ECVET recommendation [5] is missing (as well as many other items like Agreements, Memorandum of Understanding, Recognitions) in most of the products documented in these projects. As a consequence, the developed systems defining qualifications, units, LO and KSC vary to a large extent in taxonomy and in quality.

The lack of standards and specifications lead to missed opportunities to improve the usability and to create synergies to:

- exchange units and learning outcome descriptors (also recognition/assessment criteria) between organizations,
- create multilingual learning outcomes by using meta-data,
- create common databases and repositories for interoperability support.

Requirements for learning outcome descriptions are not available as well as technical specifications for an IT based processing and sharing of these data.

These findings have been confirmed also by the surveys carried out in the framework of the VITA project (http://www.vita-eu.org/), that have identified the following obstacles and weakness:

3. Lack of technical interoperability due to missing technical specifications (also leading to a lack of comparability of units and learning outcomes)
4. Missing connection between IT supported learning and assessment systems LMSs and e-Portfolios systems.

The project IMPACT tackled this issue by proposing:

- a technical specification to facilitate the interoperability of European validation and certification instruments with Open Educational Resources (OER) provider and e-learning systems to make them transferable and to increase the attractiveness and usability of validation in practice.
- A prototypical architecture that supports the integration between course delivery platforms, e-portfolio environments and validation systems.

The ECVET technical specification and the prototypical architecture are presented in details within the following sections.

1.3. The ECVET Technical Specification

To avoid re-eventing the wheel one of the first tasks was the research of existing formal ECVET specifications. Only one – created by the eCOTOOL project was found and investigated. The eCOTOOL Project started 2010 and had a duration of 2 years. The project-site is http://www.competencetools.eu.

The overall objective of eCOTOOL is to improve the development, exchange, and maintenance of VET certificates and their accessibility and transparency by harmonizing Europass with other European instruments (EQF, ECVET) and e-competences. This will increase the European mobility and transparency of VET systems.

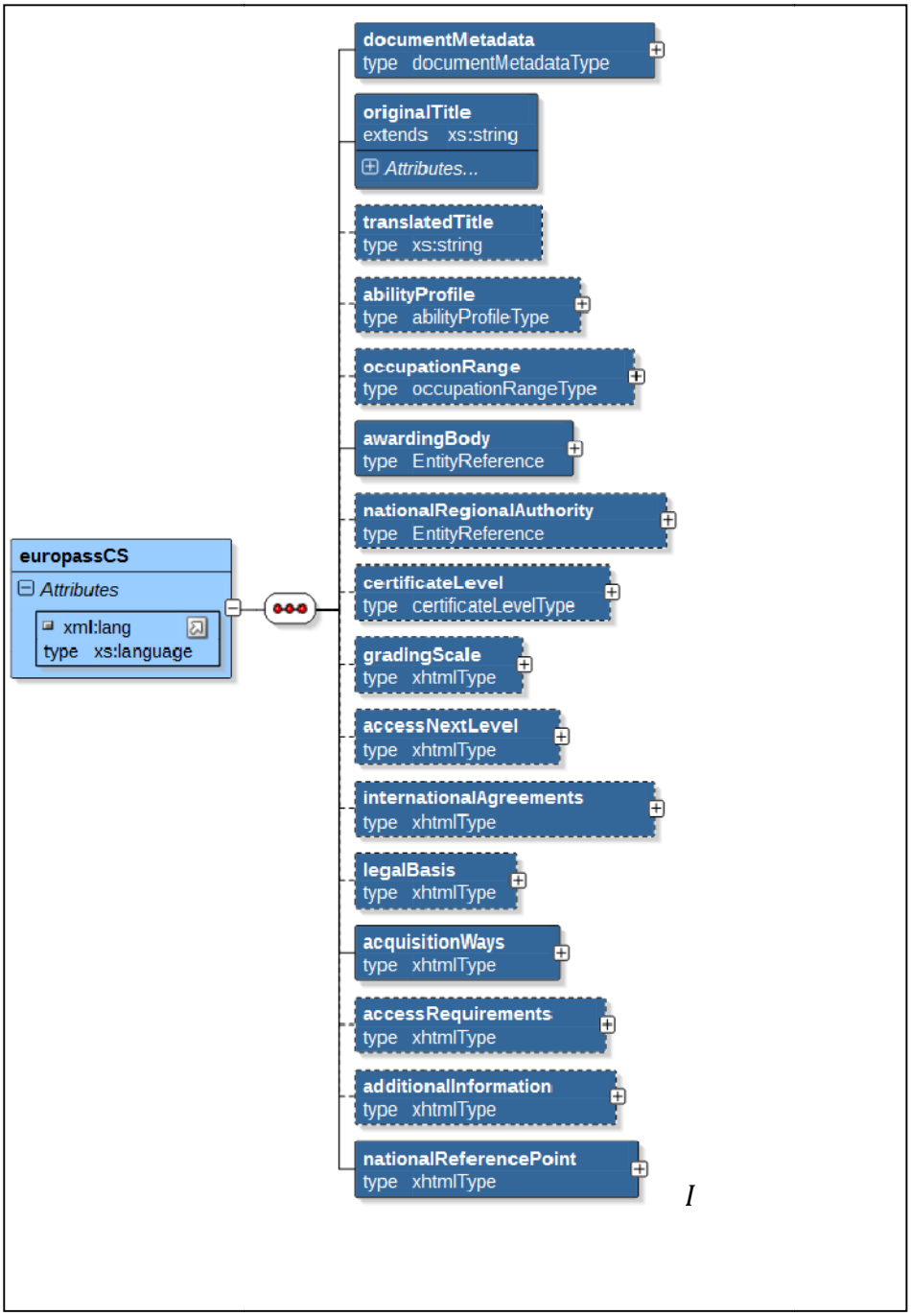


Fig. 1: eCOTOOL ECVETspecification root

ECVET Recommendation 2009		EcoTools 2011
Qualification		Original Title
Learning outcomes		Ability wrapped in ability Profile
Unit of learning outcomes (links to: ECV points assessment criteria (s.u.)) described for a single or common qualification		Missing Missing Missing
	Knowledge (references to EQF/NQF)	Missing. Missing
	Skills (references to EQF/NQF)	Missing. Missing
	Competence (references to EQF/NQF)	Missing. Missing
Credit for learning outcomes' (credit)		
Competent institution		Awarding Body, Rational regional authority
Assessment of learning outcomes		Missing in Detail
Validation of learning outcomes		Missing in Detail
Recognition of learning outcomes		Acquisition Way
ECVET points (relative weight of units)		GradingScale (possibly misunderstood)

Looking at the technical ECVET specification – developed under the project eCOTOOL – one can immediately notice the small number of defined data objects. Comparing these specifications with the recommendation, it becomes obvious that only a small number of the use cases is actually displayed by the eCOTOOL specification. The eCOTOOL specifications also make use of own labels, which does not comply with the recommendations. The dimensions of knowledge, skills and competences are completely missing in the specification as well as the recommendation to assign EQF/NQF levels directly to outcomes.

The element "ability" is a left out, hence one cannot assign sub-elements to it. It's difficult to reuse, because the lack of a metadata-classification annotation

In other places, the Recommendation seems to have been completely misunderstood. So, the specification represents a gradingScale type which has no equivalent in the recommendation. While the gradingScale describes a taxonomy, which is used in German educational institutions, the recommendation specifies the weight of the individual units in relation to the overall qualification.

Summary: The implementation of the specification is incomplete and faulty. You can assume, that the recommendation has played no significant role in the development of the specification. According requirements formulated in 2009, this technical specification is therefore absolutely useless.

Because of the lack of a serious existing specification there was the need to develop one from the scratch by investigating the ECVET recommendation and selected pilot projects.

So, the ECVET technical specification is based upon the ECVET recommendation [5]. Currently, this specification consists of all of the data types defined in the ECVET recommendation.

This schema has the aim to contribute to the specification development, in order to facilitate and standardize data collection in future ECVET pilot projects.

The main characteristics of the proposed schema can be summarised as follow:

- it uses of the same vocabulary as the recommendation
- it uses the relationships between the data types based on the definitions in Annex 1
- it is fully documented by annotations of the data types linked to the explanations in the recommendation
- it shows considerations on places where the recommendation is ambiguous or out of focus (to discuss and unify them in a final specification)
- it takes into account the official form from ecvet-info.de
- it consists of some data containers which do not 100% cover the recommendation but are useful for the electronic processing or structure

An XML schema has been implemented to represent all the concepts that the recommendation includes. The XML schema is freely available under the GPL license [7] in the http://open-ecvet.eu portal developed to make public the process that led to the development of the schema.

Even though the proposed technical specification is based on the ECVET recommendation, a large number of ECVET pilot projects were inspected in order to analyse how the ECVET recommendation was already adopted. The analysis showed that only about twenty of them reported detailed information about their 'implementation' of the ECVET framework. These projects have been analysed with reference to their compliance to the ECVET recommendation and the developed XML schema. As a result, the data schema has been modified in some parts in order to support additional data fields of the evaluated pilot projects. These data types have been annotated accordingly with the aim of distinguishing the added data fields not strictly compliant with the ECVET recommendation.

The resulting data scheme has been published on github (https://github.com/openecvet/ecvet) as an open source (under GPL license) project in order to make it available to a wider group to modify it or to be discussed critically.

The publication is also intended to disseminate project results by expanding the network of institutions using ECVET and to determine the needs of the institutions which have used or would like to use ECVET in the future. This is an iterative development process between technical specialists and users, which ensures a constant quality control and assurance.

Finally, the data schema has been mapped to a relational database to be able to enter the pilot projects into the database in order to test its consistency.

More details about the recent developments of the technical specification are available at the following web site: http://open-ecvet.eu/

This web site constitutes an access point for the dissemination for the ECVET technical specification. At the time of writing, this web site has a good rank in google search for the terms "ECVET technical specification", since it appears amongst the first five results, after web sites connected to the official technical working group of the European commission.

In Fig. 2 a part of the IMPACT ECVET-Specification is shown. The solid lines represent relations to elements which are required, e.g. an ECVET document must consist of a qualification. The dotted lines represent elements which are optional, e.g. complementary documents. These could exist, but the statements about the qualification could also be significant without them.

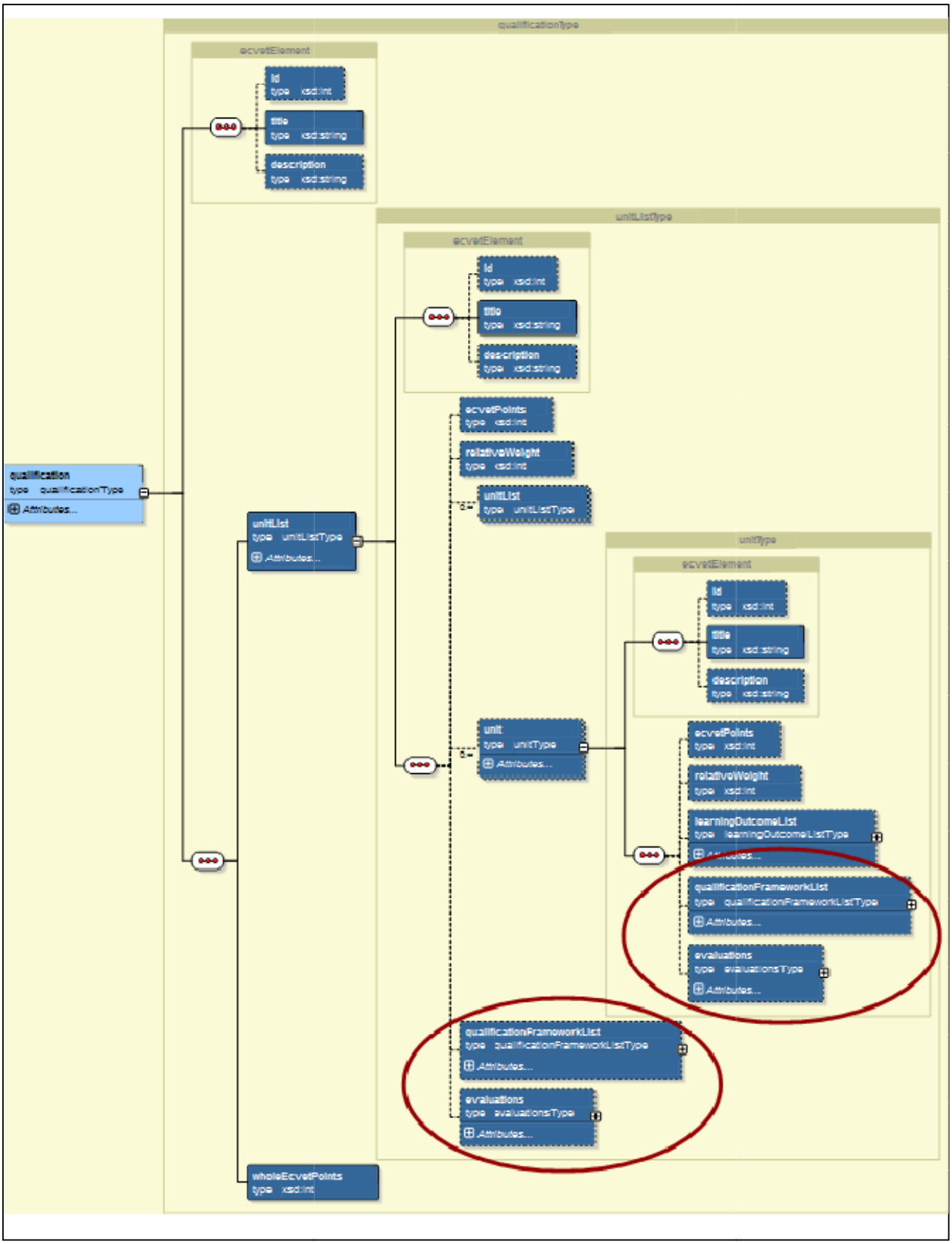


Fig 2: The Impact ECVET-Specification Qualification Element

The example shown in fig. 2 is a little bit more complex. A qualification consists of a list of units (unitList), which are containing single units (unit). Because the recommendation is ambiguous some elements occur twice. The “qualificationFrameworkList” (which consists of the EQF or NQF) as well as the “evaluation” can be mapped to a unit or a unitList. It's the task of the future to discuss which of these mappings are more appropriate. The more unique these mappings are, the easier is it to redefine, compare, find and reuse the data in a future context, where hundreds of organizations try to synchronize and unify their vocational trainings.

1.4. Implementing the ECVET Specification

In order to simplify the use of the ECVET specification a standalone Java swing application with an integrated database has been developed in IMPACT.

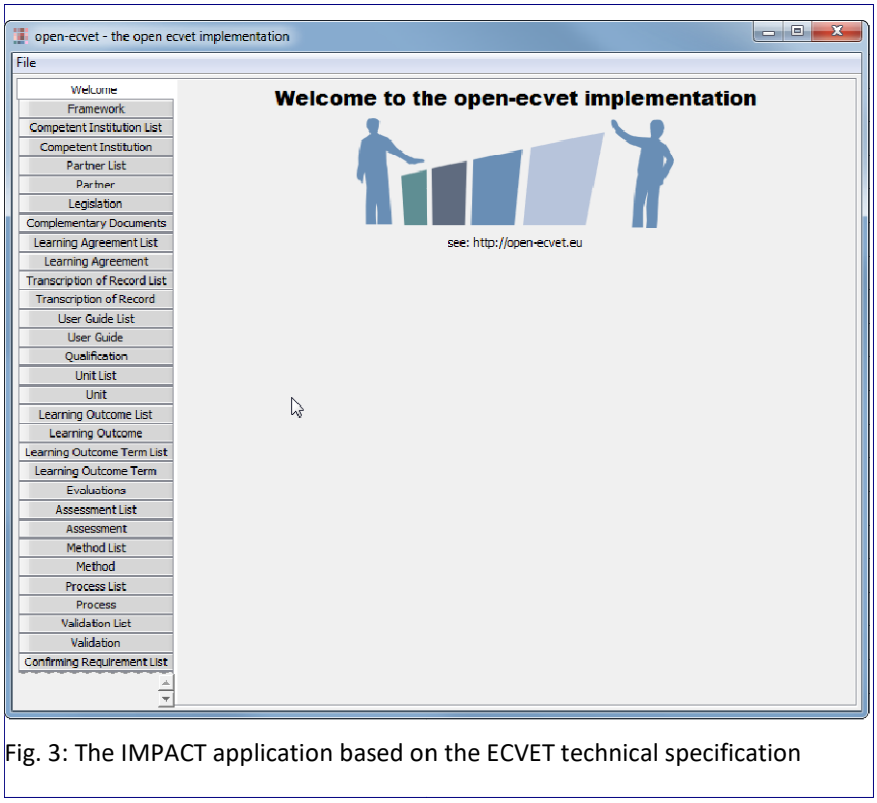


Fig. 3: The IMPACT application based on the ECVET technical specification

The application consists of a simple user interface that supports the use of the ECVET specification. To check the integrity of the underlying database, a selection of pilot projects has been used to feed the database.

A specific website was created to start an expert group on the further development of a European wide ECVET specification. The application can be downloaded from http://open-ecvet.eu/wp-content/uploads/2016/02/ecvet.zip, please note that it requires Java 8 to be executed.

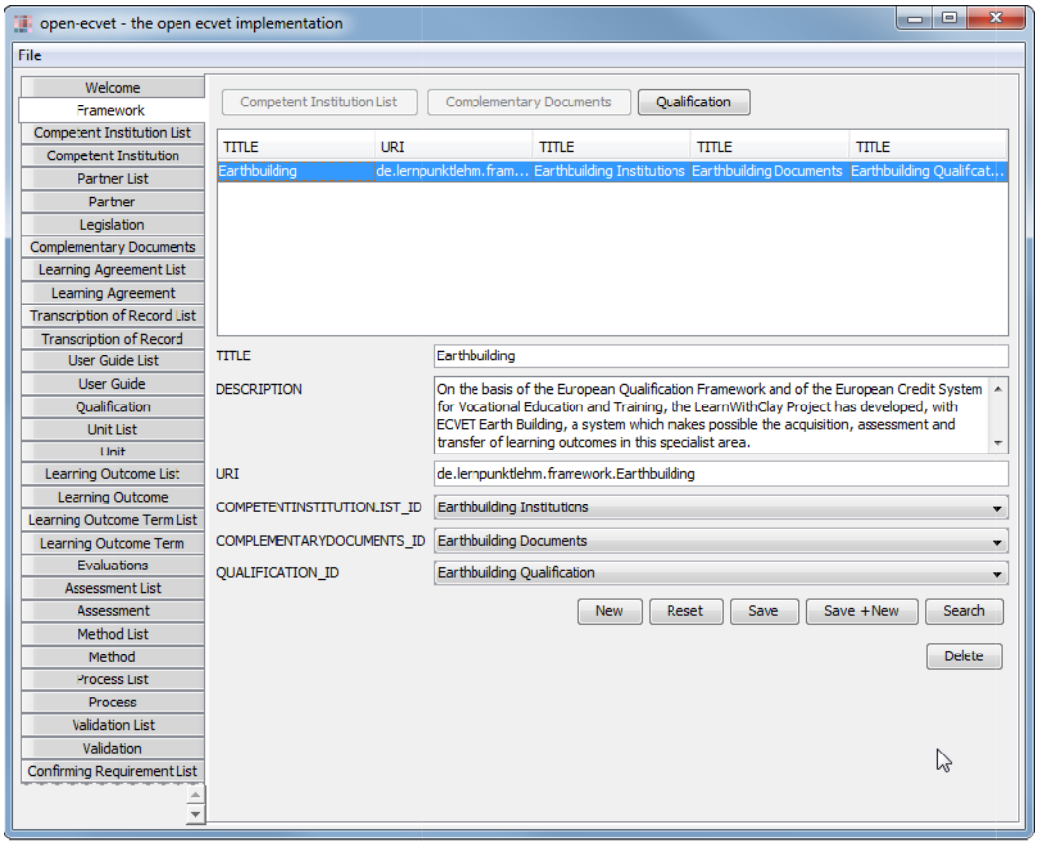


Fig 4: Supporting the adoption of the ECVET specification

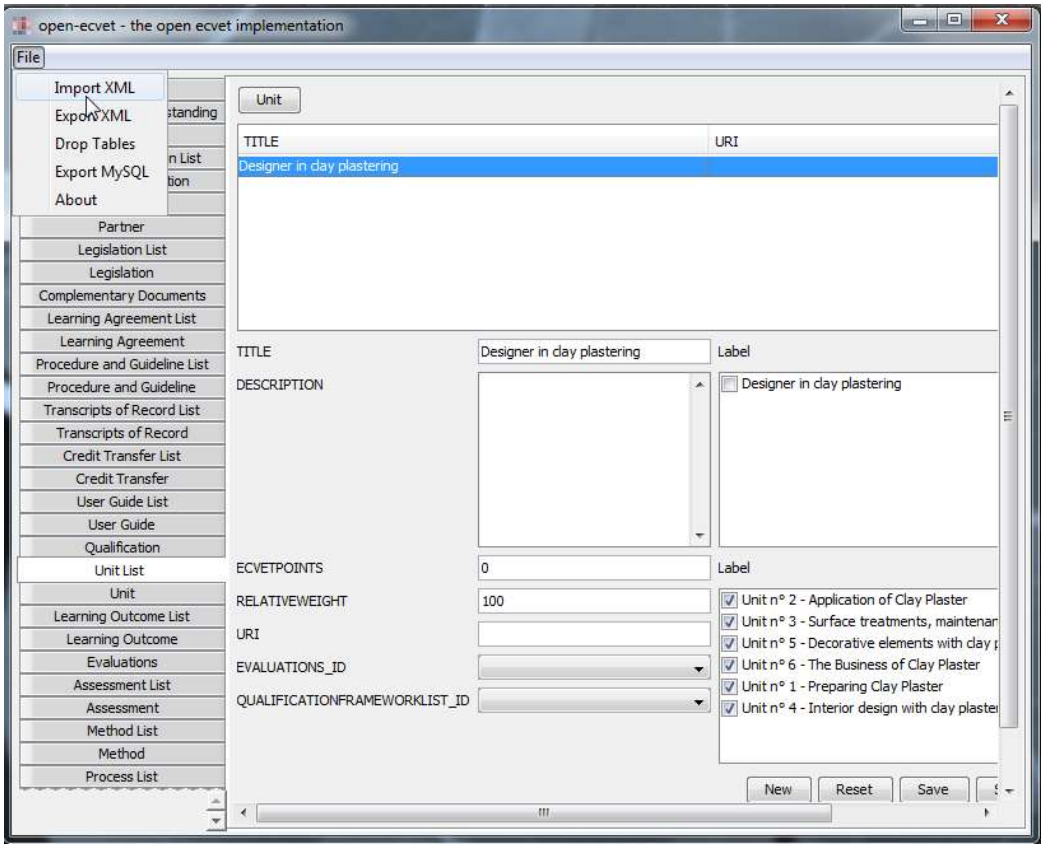


Fig. 5: Import an export from and to xml

As shown in Fig. 5 the IMPACT application is able to import and export xml-data, which is the standard format for interoperability recommended by the w3-consortium.

2. The Prototypical Architecture

The ECVET technical specification is one of the main outcomes of the IMPACT project. The specification supports the creation of a common vocabulary that can be used by different e-learning systems to share information. This is a fundamental step towards the development of an open learning space, however, the technical requirements to guarantee a fully-fledged interoperability between e-learning systems have to be defined.

To this aim, a further development carried out in the IMPACT project is the definition of a prototypical architecture to support e-learning systems integration. In particular, the main aim of this work is to suggest a prototypical architecture that exploits the existing standards to support interoperability between e-learning system.

In fact, researches in this field demonstrated that several standards have been developed with the aim to exchange learner data, define students' profiles, and describe learning outcomes and competences. The importance to describe the person's education and career development both at university and companies level have led to the definition of various standards, supported by different worldwide organizations, as reported in the following sections.

2.1. IEEE PAPI

This is a specification developed by the IEEE Learning Technology Standards Committee Working Group designed to describe learner information for communication among cooperating systems [1]. This standard stores descriptive information regarding six main categories connected to the following types of information: personal, relation, security, preference, performance and portfolio. Personal information is private information related to the learner such as name, surname, address and so on. Relations information represents learner's relationship to teachers, tutors and other students. Security information contains passwords, and other private credentials. Preference information shows information related to human-computer interactions. Performance information are connected to the learner's experience development. Finally, Portfolio information describes learner's works useful to define abilities and achievements.

2.2. IMS Learning Information Package (LIP)

This standard, defines a data model focused on the description of learners' experiences, goals and accomplishments [2]. LIP is divided into eleven categories and includes information about: educational achievement from school through to college, and other information related to professional development activities undertaken, personal achievement, relevant work experience, qualifications and education history.

To define learner competencies, these standards are related to other data models specialized in the description of competencies. Even in this field there is not a common adopted standard but there are different models with specific characteristics.

2.3. IMS RDCEO

Reusable Definitions of Competence and Educational Objective (IMS RDCEO) is a data model designed to define, describe, reference and exchange competencies and learning objectives. This is an extensible model based on XML. The undertaken data model supports the definition of competencies both in structured and

unstructured mode. The structured mode uses a collection of different types of Statements in order to define Condition, Action, Standard, Outcome and Criteria related to competencies. The unstructured mode, instead, is based on a human-readable format description.

2.4. IEEE RCD

Reusable Competency Definitions is based on the IMS RDCEO, presented above. This standard has been defined by the IEEE Learning Technology Standards Committee and consists of a data model for describing, referencing and sharing competency definitions. The RCD standard provides a formal way of representing the key characteristics of a competency, independently of the context. The main aim of this standard is the interoperability of systems based on competencies by means of a standardized common model that defines competencies.

2.5. HR-XML Competency Schema

The HR-XML Competency Schema [3] is a set of specifications developed with the aim of simplify the management of the different aspects of human resources. This specification uses two different XML schema to manage competencies: CompetencyType schema and Competencies schema. The CompetencyType is based on two main concepts: CompetencyId, SpecifiedCompetencyReferenceType. The first is used to create a reference to a single competency or a group of competencies within a specialized taxonomy. The Competencies schema is designed to support an easy and flexible management of the competencies. This standard does not define a taxonomy of competencies either tools to create an explicit mapping between elements coming from different taxonomies.

2.6. Learning Tools Interoperability

The Learning Tools Interoperability standard has the main aim of integrating learning applications often provided as services into learning platforms such as: LMS, e-portfolio, or other kinds of educational environments. The main concept behind the LTI approach is the communication between so called Tool Providers and Tool Consumers, the first are data producer, while the latter have the specific role of data processing.

2.7. Experience API (xAPI) and Learning Record Store

The Experience API (xAPI) also named "Tin Can API" is widely considered the successor of the SCORM (Shareable Content Object Reference Model) standard. The Experience API is an e-learning software specification that allows learning content and learning systems to interoperate for sharing information about records and tracks related to students learning experiences.

The repositories used to collect learning records are called Learning Record Stores (LRS). They can exist within traditional Learning Management Systems (LMSs) or as external tools.

3. Prototypical Architecture and Standards

Previous sections highlighted that, over the years, several technical standards have been developed with the aim of representing learners' profiles, competences and e-portfolio information. However, only a restrict number of them have been fully implemented in online e-learning systems.

The IMS consortium has published a table available at the following address (https://www.imsglobal.org/conformance-list) collecting the status of the Interoperability Conformance Certification of the standards published by the consortium.

A quick analysis of this table reveals that the standard that has implemented the most is the LTI (Learning Tools Interoperability), with particular respect to the version 1.0. The most part of both commercial and open source products adopts this standard to support interoperability functionalities with other tools. Even though the current version of the standard (v2.0) supports communication in both ways between learning provider and learning consumer, as stated before, the most implemented version of the LTI standard is the v1.0. This version of the standard presents a limitation in the sharing of data between learning consumer and provider, as a result of the elaboration carried out on the learning provider system.

3.1. The Prototypical Architecture in Practice

The reference architecture of our e-learning eco-system is composed by three environments:

- e-learning provider: this is a platform that deliver the e-learning course. In this platform students access to the learning materials and participate to assessment sessions.
- validation system: this platform is used by teachers to store data related to the validation of qualifications.
- e-portfolio: this platform collects all the information related to the students' curricula.

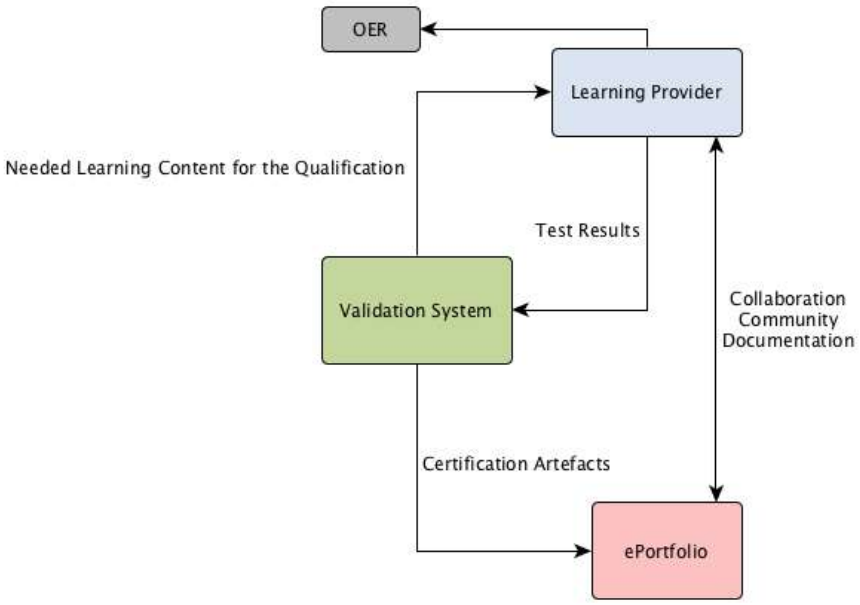


Fig 6: Key elements of the prototypical architecture

As an example, the reference architecture could be implemented by using the LMS Moodle, the LEVEL5 software as a validation system and Mahara as the e-portfolio platform.

The development of a holistic learning ecosystem, in which different platforms have to communicate and share their data, has to take into consideration this relevant information.

In fact, the architecture that is at the basis of this technical specification has the aim to propose a general approach, in which a system is identified by its role, avoiding bindings to specific platforms. In this sense, when we talk about learning provider, we refer to a general Learning Management System.

Figure 7 shows a general overview of systems and communications provided by the standard.

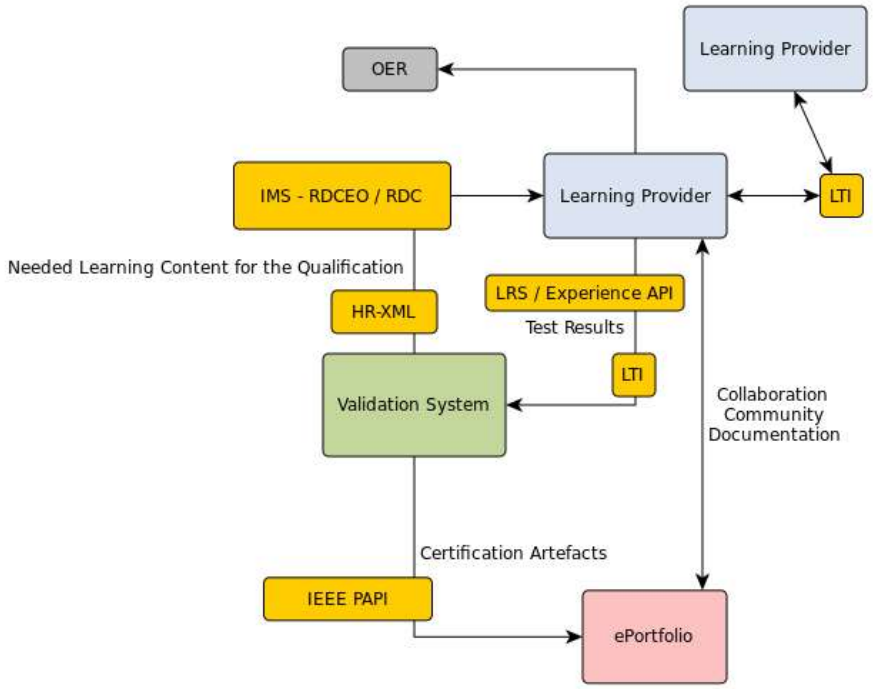


Fig. 7: Relationships between standards

3.2. Implementation of the Prototypical Architecture and Use Cases

The prototypical architecture implemented in the IMPACT project is composed by: Mahara (the my-VITA platform) to manage e-portfolio, Moodle (as a LMS) and the LEVEL5 software as a validation system.

The integration between Mahara and Moodle platforms has been developed by using the existing 'Mahoodle' – plugin to support a single sign-on solution.

The integration between Moodle and LEVEL5 platforms has been tested in two different scenarios:

- In the first scenario students of a course on the Moodle platform need to do a self-assessment on a competence described on the LEVEL5 platform. For this scenario, an implementation using the Learning Tools Interoperability (LTI) specification developed by the IMS Global Learning Consortium has been created. On the Moodle side the existing LTI tool consumer implementation (in compliance with version 1.1 of LTI) is used, on the LEVEL5 side a LTI tool provider implementation has been created (including necessary changes in the graphical user interface of the LEVEL5 software). This solution might also be used for the integration of Mahara and LEVEL5. The LTI

specification has been selected for this scenario since, amongst the huge number of available specifications designed to describe competences, students' profile and learning paths, the LTI specification has the peculiarity of being specifically designed to support interoperability and, as declared in the IMS Interoperability Conformance Certification (https://www.imsglobal.org/conformance-list), LTI is the most implemented standards by the most part of e-learning platforms.

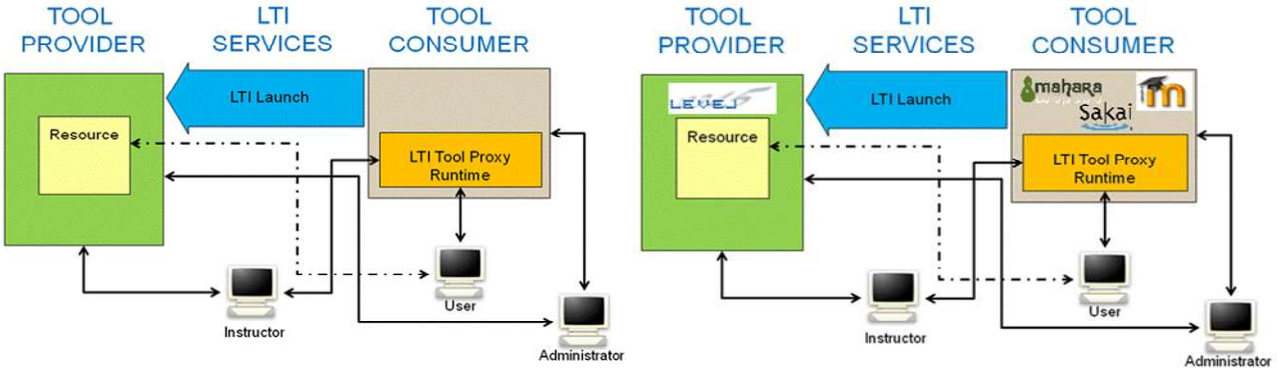


Fig. 7: Use case with LTI implementation

- In the second scenario, the students of a course on the Moodle platform need to be assessed by a 'teacher' in a competence described on the LEVEL5 platform. For this scenario, an implementation using the web service API of Moodle was chosen as no 'general' specification could be found which would have served the needs and is commonly used. For Moodle a local plug-in has been created which extends the web service API with additional functionality. For the LEVEL5 software a client for the extended Moodle web service API has been created and necessary changes in the graphical user interface have been integrated. This solution is so far Moodle specific, but a Mahara plug-in exists which implements a web service API quite similar to the Moodle web service API so that a similar solution for the integration of Mahara and LEVEL5 might be implemented.

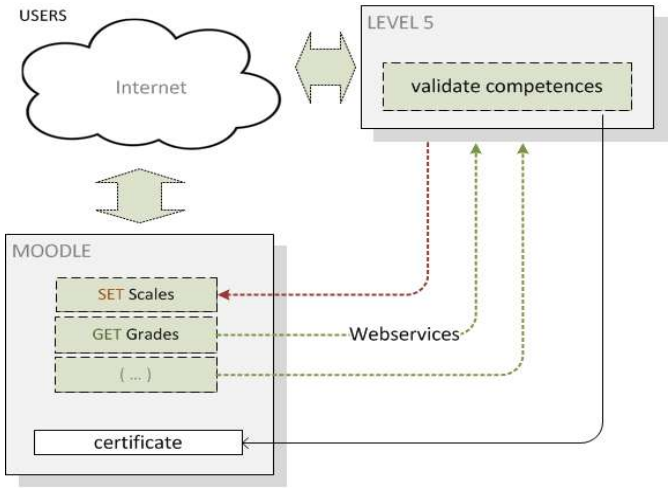


Fig. 8: use case with Moodle web services

Even though both scenarios support the exchange of information between the elements of the prototypical architecture proposed in Figure 3, in the IMPACT project the first scenario based on the use of LTI standard has been preferred. The main motivation is the wide numbers of e-learning platforms that declare to be compliant with the LTI standard. While the second use-case presented is bounded to the Moodle learning management system, the use of the LTI solution is not connected to the use of a specific platform, but all the systems compliant with LTI standard can be integrate. A testing phase conducted within the IMPACT project has the use of LEVEL 5, in two different LMS, Moodle and Sakai (see Figure 7 and 8).

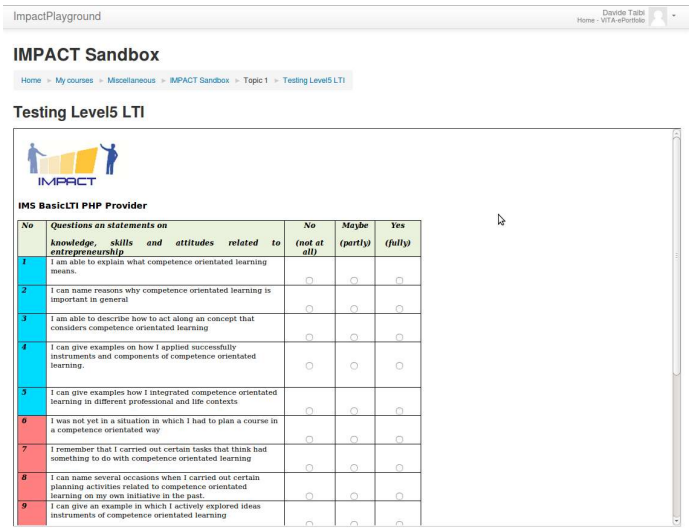


Fig 9: Testing Moodle and LEVEL5 integration

gives following result:

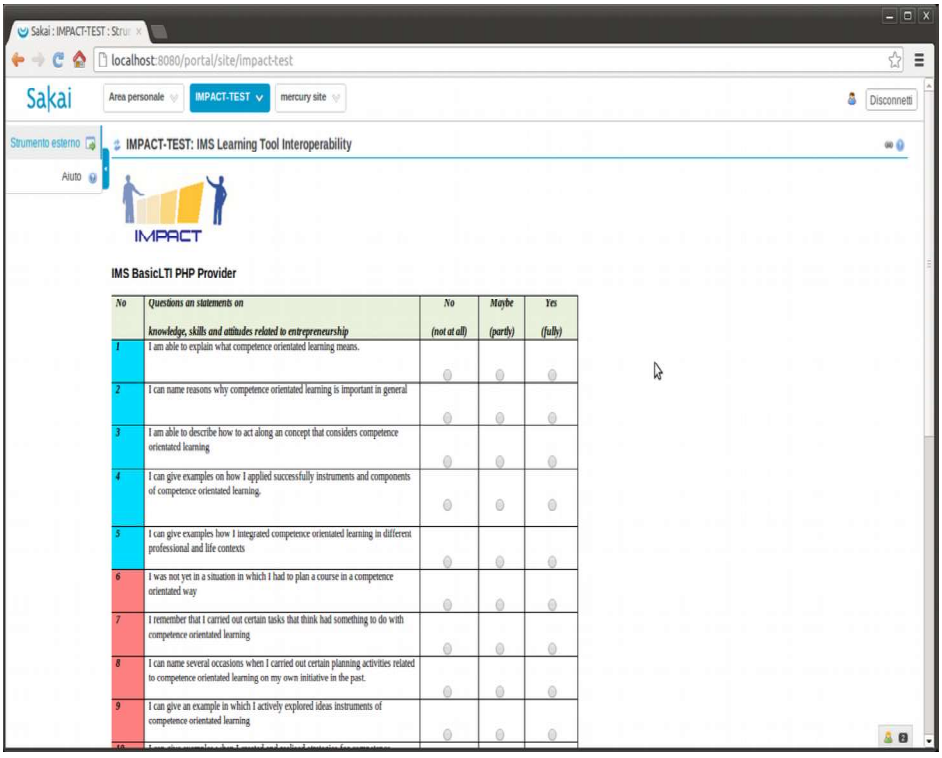


Fig 10: Testing SAKAI and LEVEL5 integration

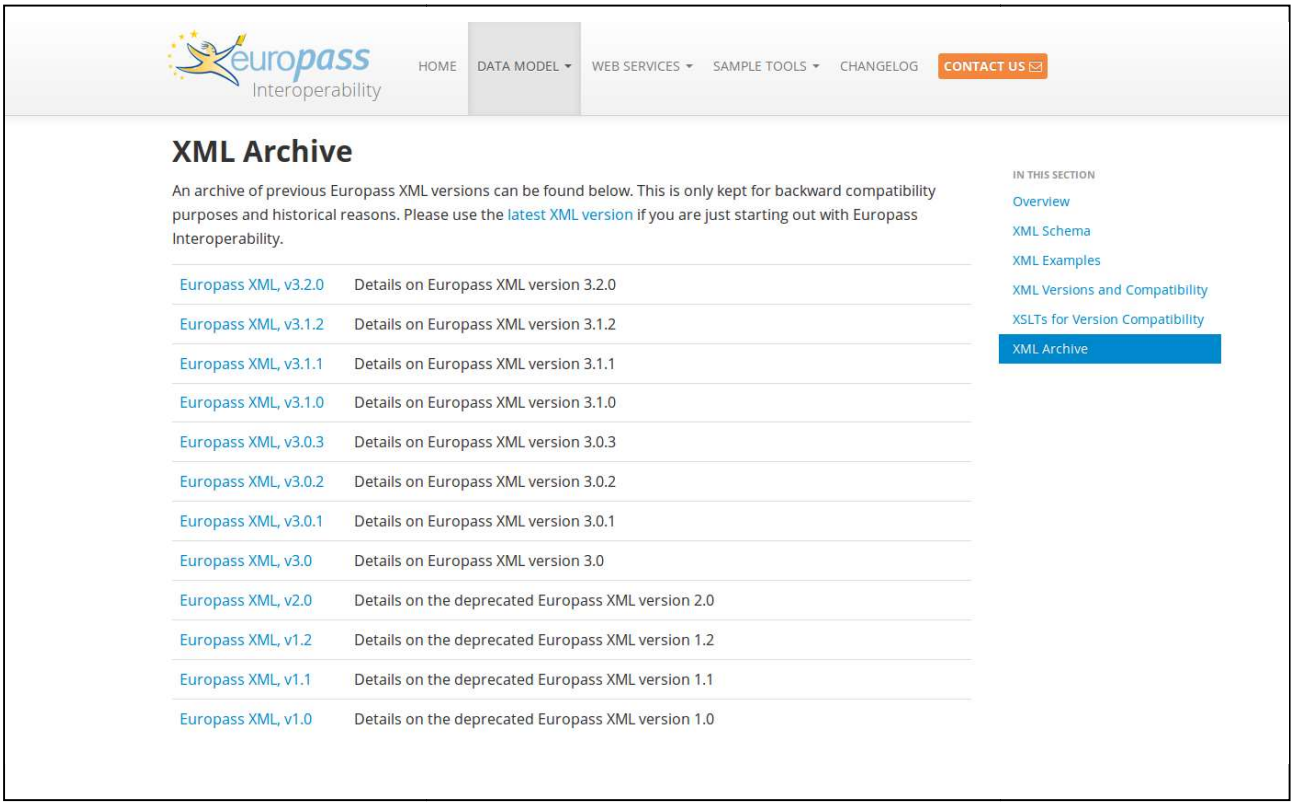


Fig. 11: EUROPASS Specification

If you analyse Fig. 12 [2] you can count 13 different versions of the EUROPASS specification modified in round about 10 years, including deprecated versions, which are not backward compatible. Factually this means, that the specification changes faster than a software company with small resources can develop an implementation. In fact, if you ask people from the educational sector, the need of an EP-implementation is high but implementations are very rare. During the IMPACT Project, the specification changes from 3.1 to 3.3.

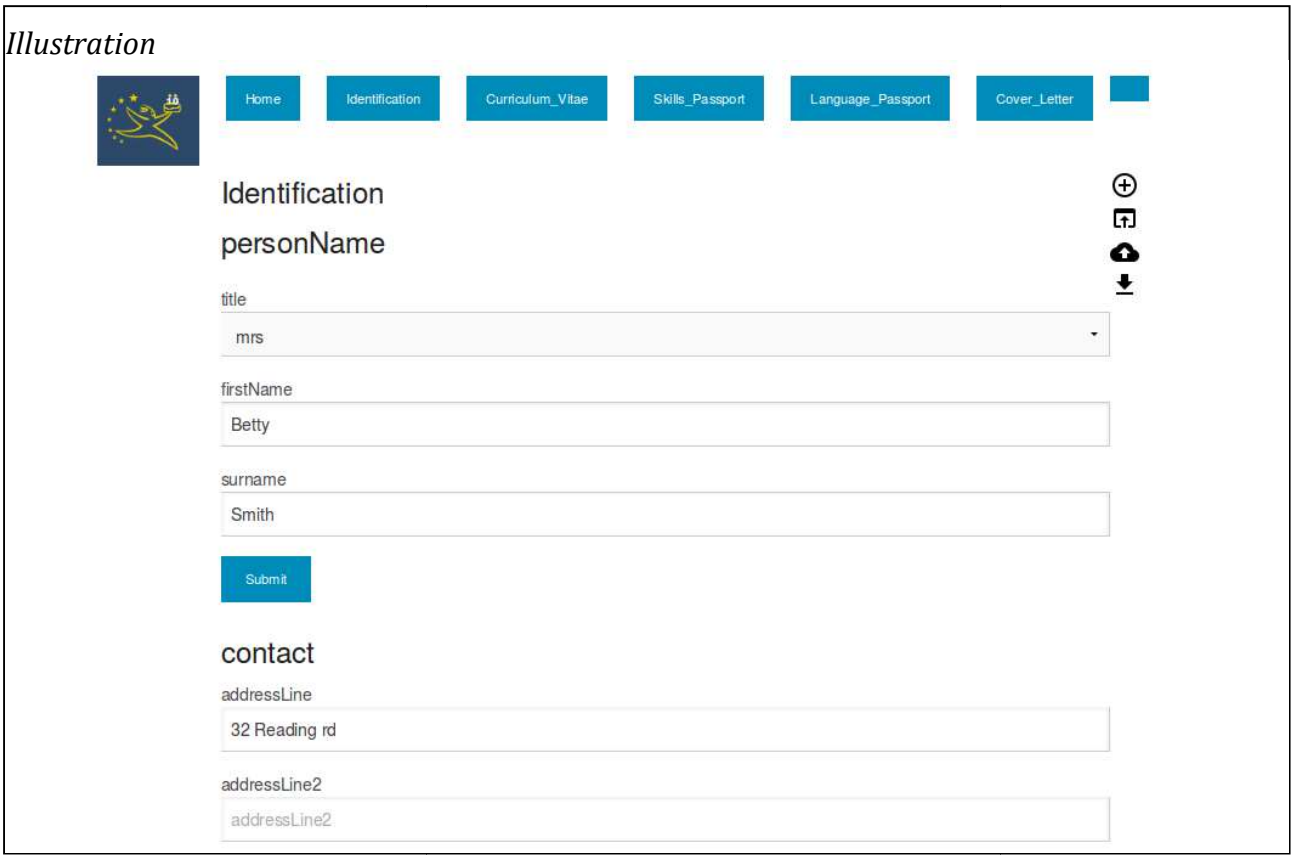
To solve this problem and make implementations of the EP-specification sustainable you must auto-generate the user interface from the formal specification. This has also the advantage, that if developed this framework once, you can implement other software, which is described in the same formal language (e.g. an ECVET user interface for organizations) quick an easy.

In order to use this strategy an open source framework (jsonix) to serialize JavaScriptData into XML has been adopted and further efforts where necessary to fix some data format issues (see: https://github.com/highsource/jsonix/commit/36095813a74ac21e958e76cea1089d316d634c08).

A software was written, which analyses the Java-Script-Data to XML mapping file from the jsonix framework and generates automatically user forms from it. To make the templates of the implementation customizable the user forms consists of “standalone” angular2-components which is currently the most common framework for html5 components, developed by GOOGLE with special programming-language (typescript) support from Microsoft.

2 http://interop.europass.cedefop.europa.eu/data-model/xml-resources/

Illustration



5. Fig. 13: EUROPASS Implementation

By using this implementation, it is possible to open and save Europass in XML documents in which initials input and output fields are dynamically created during runtime. From a technical point of view, the code-quality is ensured internally by means of unit tests included in the implementation.

The alpha version of the Europass module is available at: http://europass.q21.de/

4. Future Developments

In the framework of the IMPACT project, the technical team is finalizing an ontology to represent concepts of the ECVET recommendation and the relationships between concepts. The ontology is based on the work carried out by the technical team to define the XML schema with the main elements defined into the ECVET recommendation.

The availability of such an ontology will provide the basis to:

- support interoperability between e-learning systems;
- semantically represent pilot projects in the ECVET domain;
- create a dataset of ECVET projects linked with other resources in the Linked Data cloud;
- set-up a SPARQL end-point in which information about ECVET projects can be accessible in a machine-readable way.

- There are strong links between IMPACT and the project OWL, which is a large-scale learning platform for Adult Education Professionals which may probably make use of the findings and developments made in IMPACT from 2017 onwards.

5. References

[1] IEEE P1484.2.1/D8, 2001-11-25 Draft Standard for Learning Technology - Public and Private Information (PAPI) for Learners (PAPI Learner) - Core Features Sponsored by the Learning Technology Standards Committee of the IEEE Computer Society. Institute of Electrical and Electronics Engineers, Inc. 3 Park Avenue, NY 10016-5997, USA (2001)

[2] Smythe, C., IMS Learner Information Package Summary of Changes - Version 1.0.1 Final Specification, IMS Global Learning Consortium, Inc, (2005)

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