D4.4 Studying Abroad – Final running phase

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List of Acronyms

Abbreviation/ acronym	Description
AMA	Administrative Modernization Agency
API	Application Programming Interface
AS4	Applicability Statement 4
CEF	Connecting Europe Facility
DC	Data Consumer
DE	Data Evaluator
DE4A	Digital Europe for All
DE4A OOP TS	Infrastructure of common components implementing the Once Only Principle as created by and used in the DE4A piloting context
DID	Decentralized Identifier
DO	Data Owner
DP	Data Provider
DPO	Data Protection Officer
DR	Data Requestor
DT	Data Transferor
Dx.y	Deliverable number y, belonging to WP number x
EBSI	European Blockchain Services Infrastructure
EC	European Commission
eID	Electronic Identity
eIDAS	Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC
ESSIF	European Self-Sovereign Identity Framework
EU	European Union
eVŠ	Central evidence system for higher education in Slovenia
FERI	Faculty of Electrical Engineering and Computer Science
GDPR	General Data Protection Regulation
ID	Identity
INESC-ID	Instituto de Engenharia de Sistemas e Computadores: Investigação e Desenvolvimento em Lisboa
IST	Instituto Superior Técnico
IT	Information Technology
JSI	Jozef Stefan Institute
MIZŠ	Ministry of Education, Science and Sport of the Republic of Slovenia
MoU	Memorandum of Understanding
MS	Member State
NREN	National Research and Education Network
OCSP	Online Certificate Status Protocol
OOP	Once-Only Principle

Abbreviation/ acronym	Description
PKI	Public-Key Infrastructure
PST	Pilot Supervisory Team
SA	Studying Abroad
SDG WG	Single Digital Gateway Working Group
SDGR	Single Digital Gateway Regulation
SGAD	Secretaría General de Administración Digital
SMP	Service Metadata Publisher
SSI	Self-Sovereign Identity
STEM	Science, Technology, Engineering, Mathematics
TIR	Trusted Issuer Registry
TWG	Technical Working Group
UC	Use Case
UJI	Universitat Jaume I
UM	University of Maribor
USI	User-Supported Intermediation
VC	Verifiable Credential
VP	Verifiable Presentation
WG	Working Group
WP	Work Package
WP2	DE4A Architecture vision and framework WP
WP3	DE4A Semantic interoperability solutions WP
WP4	DE4A Cross-border Pilots for Citizens and Business and Evaluation WP
WP5	DE4A Common component design & development WP
WP6	DE4A Sustainability impact and new governance models WP
WP7	DE4A Legal and ethical compliance and consensus building WP
WP8	DE4A Stakeholder dialogue, dissemination and communication WP

Executive Summary

The Studying Abroad (SA) pilot of the "Digital Europe for All" (DE4A) project focused on Higher Education students with virtual or physical mobility needs in the European Higher Education Area. By piloting three use cases (UC#1 - Application to public higher education, UC#2 - Applying for a study grant, and UC#3 - Diploma recognition) it aimed to validate processes/procedures (c.f. Annex II of SDGR[5]) for students from the three participating Member States (Portugal, Slovenia, and Spain) for registration to higher education abroad and eventually applying for a student grant as well as for studies recognition. The pilot includes the achievement of two planned iterations, the first from February 2022 to July 2022, and the final (second) running from October 2022 to March 2023.

This document reports the progress achieved in the studying abroad pilot at the end of the final iteration, covers different users' perspectives related to piloting dimensions of Use, Value and Learning for Adoption, and provides evidence through qualitative and quantitative metrics of the fulfilment of previously defined success and technical common criteria related to the original technical and business objectives of the pilot. Following feedback from the first pilot iteration described in D4.3 [3] and the updates to the common components and interaction patterns by WP3 and WP5, pilot-specific Data Consumers and Data Providers have adapted their procedure and evidence portals, and data services (Data Evaluators, Data Owners) and implemented the activities required to connect their infrastructures (national OOP infrastructure) to the respective final common building blocks and components for interoperability across borders (Data Requestors - DRs, Data Transferors - DTs).

The main characteristics of the final running phase of the SA pilot are summarised below:

- Several changes and improvements based on the feedback on the design, customization, implementation, and testing in the first iteration were made in close collaboration with other Work Packages responsible for semantic interoperability solutions and common components design and development:
  - additional support of enrolment to the first Bologna degree studies (Bachelor's degree) in Slovenia and Portugal,
  - an extension of a higher education diploma canonical evidence with an average grade element,
  - provision and support of additional canonical evidence types in UC#1 (proof of completion of secondary education) and UC#2 (large family evidence, disability evidence),
  - support of multi-evidence case (multiple evidence types) in UC#2,
  - implementation of a new way of user redirection in UC#1 and UC#2,
  - implementation of optimized VC pattern in UC#3, and
  - 100% increase of real students piloting the procedures;
- Two evidence exchange patterns (User-supported intermediation – USI used in UC#1 - Application to public higher education and UC#2 - Applying for a study grant, and Verifiable credentials – VC used in UC#3 - Diploma recognition) and four evidence types were piloted with real students;
- Six data evaluators/verifiers and six data owners/issuers have been successfully customized and integrated with the eIDAS infrastructure and the DE4A OOP TS or EBSI infrastructure (see Section 2.1). All data owners/issuers were able to provide real higher education diplomas;
- Interoperability between all three MS (Portugal, Slovenia, Spain) has been achieved (see Section 2.3). All 12 planned cross-border combinations between DEs and DOs or Issuers and Verifiers were successfully piloted with real students: 6 combinations in UC#1, 2 in UC#2, and 4 in UC#3;
- Various strategies to avoid infrastructure delays have been defined and applied throughout the two piloting iterations overcoming significant challenges in this process (see Section 2.2 and D4.3 [3]);
- Feedback on satisfaction with the piloted services was obtained from a total of 104 students via an online questionnaire (see Section 3.2.1). The most valued aspects of the piloted procedures (on a scale from 1 to 5) were the duration of the procedures (4.26), control in managing own credentials (4.16), security and privacy protection (4.09), and required effort (4.02), while the least appreciated

was the number of errors and interruptions (3.52). Compared to the first iteration, the share of students who were satisfied or very satisfied with the overall experience increased by 10 percentage points to 66%. The majority of the students who provided feedback on the Explicit Request and Preview common also appreciated the clarity of these two functionalities. Students' feedback was used to generate one success story and the results for corresponding pilot metrics in the final iteration (see Section 3.2.1);

- Feedback on the benefits of the piloted services was obtained by a questionnaire as well as by interviewing university administration staff, e.g. student office staff in Higher Education Institutions from Slovenia, Spain, and Portugal (see Section 3.2.2). Their experiences show, for example, that DE4A procedures can save significant time in processing students' information, especially in the validation of higher education diplomas, from 20 and 30 minutes per foreign student in the cases of Portugal and Slovenia respectively to up to several days in the case of Spain. The respondents also appreciated the quality of received students' data, especially the correctness and reliability of the data, and availability in electronic format. Feedback was used to generate three success stories and the results for corresponding pilot metrics in the final iteration;
- Feedback on the usefulness of the common components and specifications was collected from pilot partners and other organisations involved in the customization, implementation, deployment, and testing of Data Evaluators - DEs, Data Owners DOs, or infrastructure (see Section 3.2.2.4). The institutions highly appreciate the common components, especially the Kafka server (4.40) and the central SMP (4.29) in the playground, and the DE4A connector (4.24);
- Based on the feedback, lessons learnt and suggestions for adoption were gathered in different steps (see Section 3.2.3). For the analysis and design phase, the pilot recommends re-evaluation of the scope of the SDG regulation to some higher education use cases, harmonization of the evidence data models defined separately by SDG WG and Europass, and a temporary solution for the use of non-notified eIDs in SDG procedures. The lessons learnt in the customisation, integration, and testing phase mainly relate to the usefulness of the DE4A connector, the documentation, and the collaboration between the developers.

In addition to the Studying Abroad pilot, the pilot results were also used to validate in operational environments and with real users multiple outcomes from other DE4A activities, in particular, "WP2 Architecture vision and framework" (validation of the project start architecture, the User-supported Intermediation pattern, and the Verifiable Credentials pattern), "WP3 Semantic interoperability solutions" (validation of canonical data models for higher education), WP5 - Common component design & development (validation of the common components such as DE4A Connector and SSI Authority Agent, and the underlying evidence exchange infrastructure - DE4A OOP Technical System - and the integration achieved with EBSI infrastructure), and "WP7 Legal and ethical compliance and consensus building" (legal outcomes of the final iteration). Furthermore, pilot results and activities have been used by "WP6 Sustainability impact and new governance models" (business models and new models for shared delivery of common services), and towards "WP8 Stakeholder dialogue, dissemination and communication" (dissemination and communication activities).

Collaboration between several institutions from Portugal, Slovenia, and Spain in the Studying Abroad pilot has proven tangible benefits from the secure, high-quality, and user-centric cross-border exchange of evidence for online Higher Education procedures that will greatly facilitate student mobility in Europe and significantly reduce administrative burdens. The pilot has contributed to the expected DE4A benefits as a project and in relation to the external community of SDG stakeholders in several ways. It has validated the project start architecture, the User-supported Intermediation, and the Verifiable Credentials patterns, as well as the canonical model for higher education diplomas. The pilot has also validated the common components such as DE4A Connector and SSI Authority Agent and the underlying evidence exchange infrastructure. Finally, the pilot partners have provided feedback to the SDG semantic working group on the higher education evidence scheme.

1 Introduction

The Studying Abroad (SA) pilot of the "Digital Europe for All" (DE4A) project aimed at demonstrating in practice the benefits for different European Higher Education Area stakeholders of realizing across borders the principles of "Once Only" and "Digital-by-default". By the combination of three use cases (UC#1 - Application to public higher education, UC#2 - Applying for a study grant, and UC#3 - Diploma recognition) it validated during two iterations adding 12 months of cross-border piloting in realistic operational environments online processes/electronic procedures for students of the three participating Member States (Portugal, Slovenia, and Spain), for registration to higher education and eventually applying for a student grant as well as for studies recognition.

In the project's final running phase, realising progress from the initial Minimum Viable Product to fuller extended scopes, the pilot partners focused on monitoring pilot running services, gathering data and feedback from all stakeholders (Data Evaluators, Data Owners, Member States, and students), and providing support to pilot users. Use cases were officially launched after the different testing phases (of common infrastructure interoperability components and the connected pilot services) were successful and the necessary trust conditions were satisfied.

This document is related to the previous pilot deliverables "D4.1 Studying Abroad – Use Case Definition & Requirements" [1], "D4.2 Studying Abroad – Pilot Planning" [2], and "D4.3 Studying Abroad – Initial Running Phase" [3] and assumes that the reader is somewhat familiar with their content, as more details on use cases, architecture, and pilot objectives were provided there. It also provides occasional updates on the three documents.

1.1 Purpose of the document

The main purpose of this deliverable is to report on the execution of the pre-running phase activities that led to the pilot launch, describe the final running phase of the SA pilot, evaluate the collected data and feedback according to the criteria and with metrics described in the pilot plan (D4.2 [2]), and present the pilot consolidated results and findings from both iterations, including lessons learnt and success stories valuable for future adopters.

Following the feedback from the initial running phase described in D4.3, pilot-specific Data Evaluators and Data Owners have adapted their procedure and evidence portals and implemented the activities required to connect their infrastructures to the respective common building blocks and components for interoperability across borders. In coordination with WP3 and WP5, updated common building blocks and components have been integrated and tested before the launch of the procedures in the pilot's final iteration.

The document has been prepared in close cooperation with all SA pilot partners. In the current project phase, the pilot partners attended weekly pilot meetings, carried out customization and integration activities, participated in regular Connectathons, assessed the common components and benefits of the integrated procedures, and actively participated in multiple project-wide alignment meetings and alignment meetings with other initiatives, like EBSI/ESSIF [4]. Recommendations given to the pilot in D4.13 Methodology and Mid-term Evaluation report ([7]) have been considered and input for the final evaluation of the pilot (D4.14 Pilots Final Evaluation Report).

1.2 Structure of the document

This document is divided into five main sections:

- Chapter 1 – The current section that describes the purpose and structure of the document.

- Chapter 2 – It describes the final pilot status, in particular the integrated Data Evaluators and Data Owners and their cross-border interoperability status, strategies used to mitigate infrastructure delays, and updates of the metrics since the first iteration (presented in D4.3 [3]).
- Chapter 3 – Here, the pilot goals and success criteria are reviewed first and then take-up by pilot stakeholders, verified benefits, and lessons learnt in the final running phase are described. This chapter also covers feedback obtained from the pilot run with real users.
- Chapter 4 – This chapter describes pilot procedures of the final running phase, such as cross-border interoperability testing and user engagement.
- Chapter 5 - The main body of the document concludes with an overview of the main achievements and conclusions reached.

2 Final achieved status of the pilot

The Studying Abroad pilot was completed in March 2023. By the end, all three cross-border use cases were piloted successfully in Portugal, Slovenia, and Spain. This section presents the data evaluators and data owners piloted in the final phase and reports on the status of cross-border interoperability.

2.1 Catalogue of services and status

2.1.1 Use cases

Three use cases were defined and piloted:

- Use case 1: The first use case focused on the procedure of applying for admission to public higher education institutions. This procedure corresponds to the "Submitting an initial application for admission to public tertiary education institution" procedure from Annex II of the SDGR [6]. Portugal, Slovenia, and Spain were involved in this use case. Portugal and Slovenia implemented applications to both Bachelor and Master studies, while Spain only to Master studies because enrolment in Bachelor studies is a matter of regional governments.
- Use case 2: The second use case focused on the procedure of applying for a study grant abroad. This procedure corresponds to the "Applying for a tertiary education study financing, such as study grants and loans from a public body or institution" procedure from Annex II of the SDGR [6]. Slovenia and Spain participated in this use case: Slovenia as the Data evaluator and Spain as the Data owner.
- Use case 3: The third case focused on diploma recognition to facilitate the use of such information by the government and other sectors. This procedure corresponds to the "Requesting academic recognition of diplomas, certificates or other proof of studies or courses" procedure from Annex II of the SDGR [6]. Portugal, Slovenia, and Spain were involved in this use case (Spain only as an issuer of verifiable credentials).

2.1.2 Data evaluators

Table 1 summarises the endpoint URLs, the type of the provided procedures, and the status of the data evaluators at the end of the pilot. Four organisations in Portugal, Slovenia, and Spain have customized six eProcedure portals and integrated them either with DE4A OOTS (USI evidence exchange pattern) or with the SSI Authority agent and EBSI (VC evidence exchange pattern).

Table 1: Data evaluators (DE) in the Studying Abroad pilot

Data Evaluator	Use case	URL	Procedure type	Status
ES-UJI[1]	UC#1	https://preinscripcio.uji.es	Real procedure in production	Launched, piloting completed
PT-INESC-ID	UC#1	https://de4a-portal.gsd.inesc-id.pt:8443/	Simulated procedure	Launched, piloting completed
	UC#3	https://de4a-portal.gsd.inesc-id.pt:8443	Simulated procedure	Launched, piloting completed
SI-MIZŠ	UC#1	http://srvas2.rrc.si/prijava/	Real procedure in preproduction	Launched, piloting completed

[1] ES-UJI has integrated the enrollment service with DE4A connector only for Master's degree studies.

Data Evaluator	Use case	URL	Procedure type	Status
	UC#3	http://srvas2.rrc.si/prijava/	Real procedure in preproduction	Launched, piloting completed
SI-JSI	UC#2	https://grants.e5.ijs.si	Simulated procedure	Launched, piloting completed

Walkthroughs and guidelines for the launched DEs are available at https://www.de4a.eu/studyingabroadpilot.

Universitat Jaume I (ES-UJI)

The Data Evaluator ES-UJI from Spain is a corporate service for student programme pre-enrolment (see Figure 1). Anyone wishing to apply for an opening in any of the offered education programmes at UJI will access this service during the official application periods and will be guided through the process, where all the required information and documentation will be provided for the programme managers' consideration. Students coming from countries participating in DE4A's SA Pilot and applying for Master studies can explicitly request to securely retrieve (through the User-Supported Intermediation evidence exchange pattern and DE4A OOP Technical System) their higher education diplomas from the official repository in the country where they took their undergraduate studies (see Figure 2).

The service is running in production. However, it can only be accessed during official periods when the students can apply for an opening in the offered courses, which happens at different times of the year, depending on the nature of each study programme. To facilitate access to real production tests of the application with focus groups outside of the official application periods, UJI has activated the test course pre-enrolment line whenever an official enrolment is not available, but to access this line students need to be whitelisted. Details on how to get whitelisted and how to use the service are provided on the Studying Abroad pilot microsite [5].

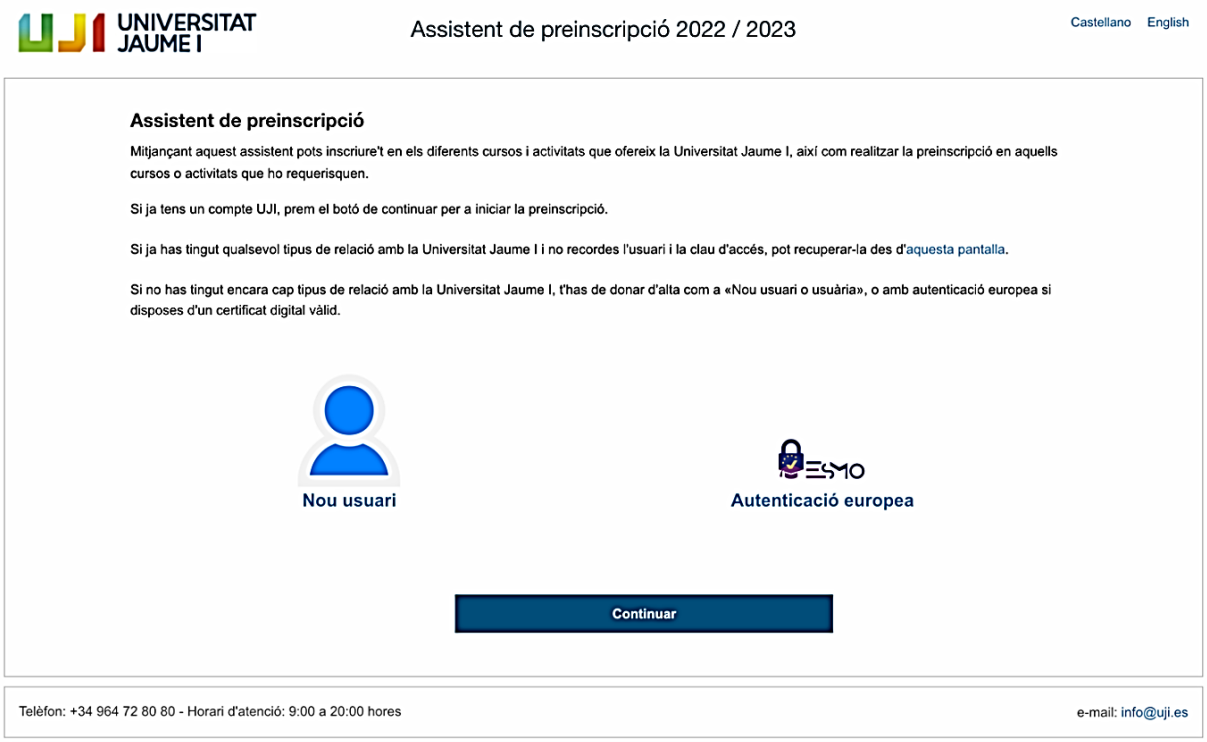


Figure 1: Pre-enrolment service at UJI

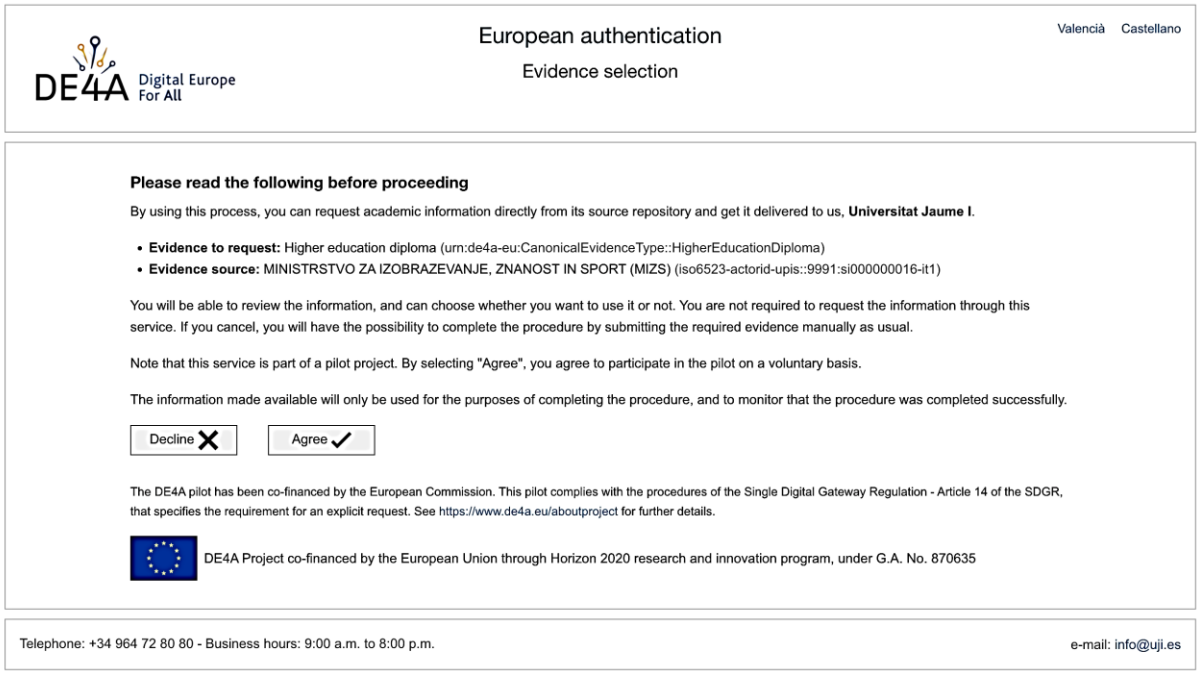


Figure 2: Explicit request at UJI

INESC-ID (PT-INESC-ID)

INESC-ID has set up a prototype portal for students to apply to Bachelor and Master programmes at Instituto Superior Técnico, the engineering school of Universidade de Lisboa, and integrated it with the DE4A Connector and the SSI Authority Agent. Candidates willing to apply for Bachelor and Master programmes at IST would access this service and be guided through the process, where all the required information and documentation would be provided for the programme managers' consideration to award the openings (in the official production portal). Students coming from countries participating in DE4A SA Pilot can explicitly request to use DE4A OOP TS to securely retrieve their higher education diploma or secondary education diploma data ("evidence") from the official repository in the country where they took their previous studies, and this is done automatically but with the Explicit Request and after Preview by students (employing the User-Supported Intermediation pattern).

The same portal can be used by students that finished their studies in another European country to have their diploma recognized. Students authenticate on the site, upload from their mobile wallets diplomas in the form of a Verifiable Credential (VC), and request recognition. Later, they can authenticate again and get information about the success of the request. Details on how to use the services are provided in the Studying Abroad pilot microsite [5].

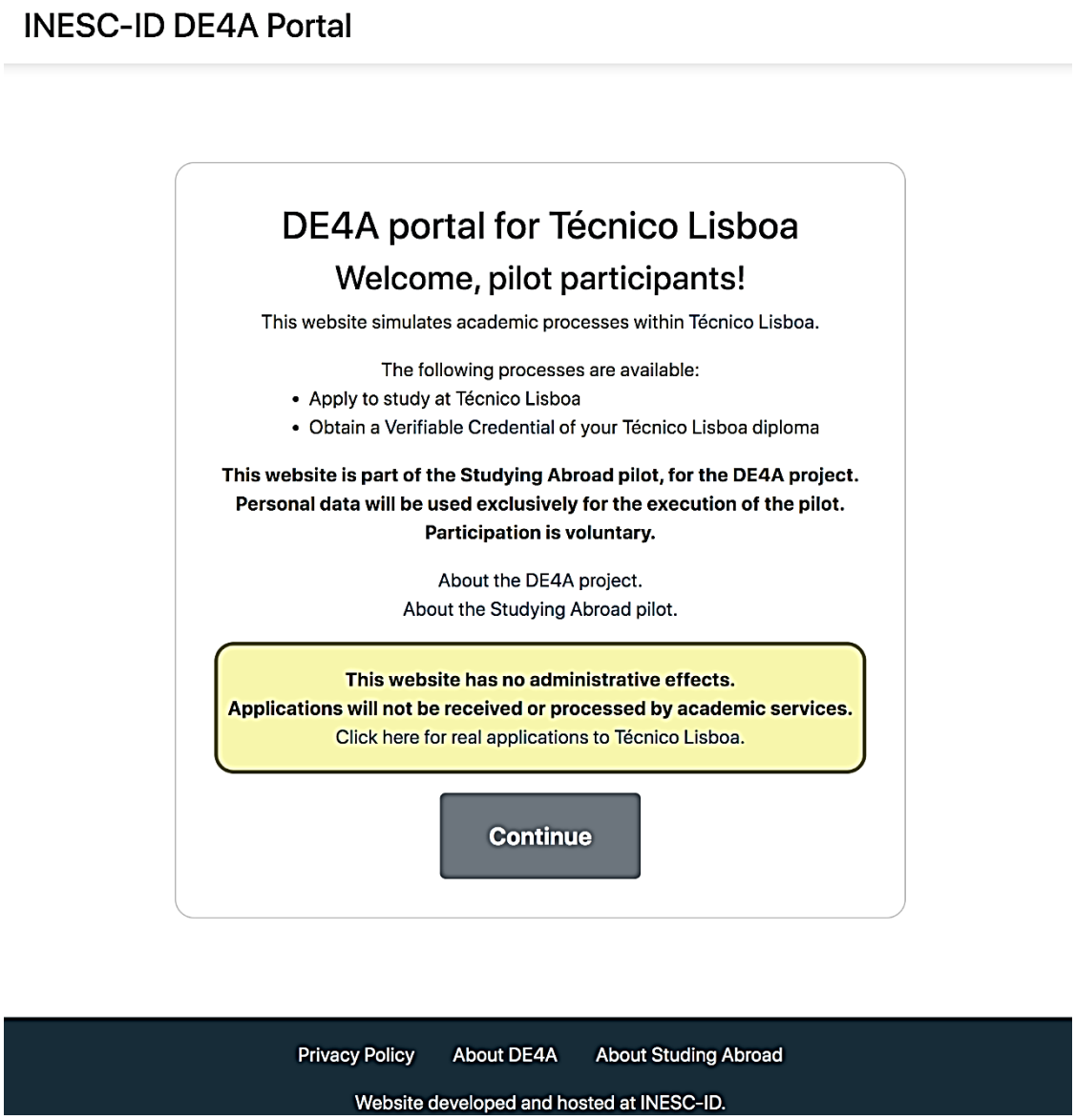


Figure 3: Prototype application portal at the University of Lisbon

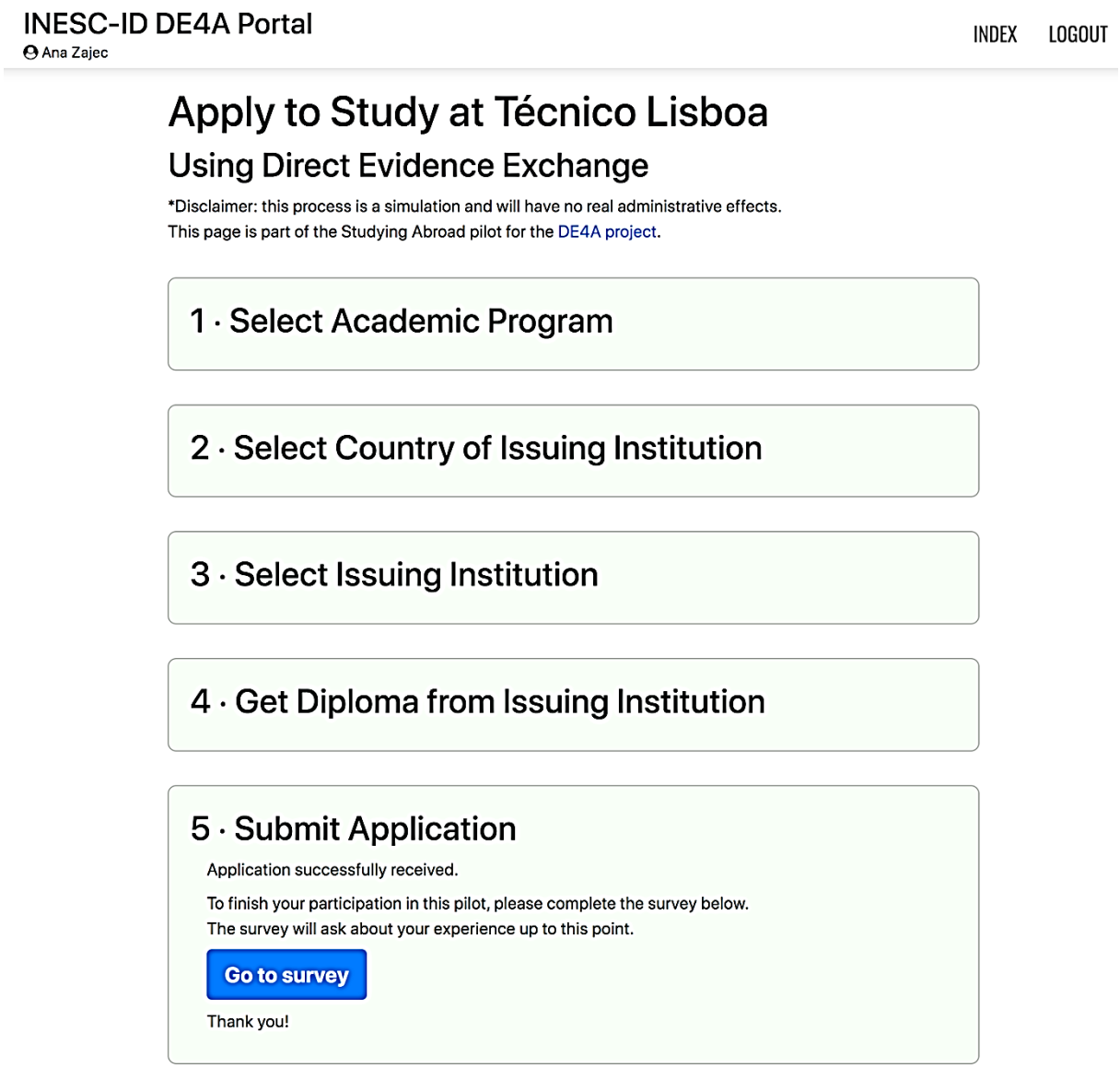


Figure 4: Acknowledged application in Master studies at the University of Lisbon in UC#1

Ministry of Education, Science and Sport of the Republic of Slovenia (SI-MIZŠ)

Since 2012 the Ministry of Education, Science, and Sport of the Republic of Slovenia has been operating the eVŠ system (the records and analytical information system of higher education in the Republic of Slovenia). Every candidate who wishes to enrol at one of the Slovenian higher education institutions must submit an application through this system.

For the final running phase, the eVŠ service in preproduction has been enabled for enrolment to both Bachelor and Master studies and integrated with the DE4A Connector and the SSI Authority Agent. As part of the procedure, real students can select the source of their real or test higher education degree diploma (an authentic source in another country for the USI pattern or a verifiable credential on a mobile phone for the VC pattern) and use the service, however without legal consequences (pilot students are not officially enrolled to higher education in Slovenia).

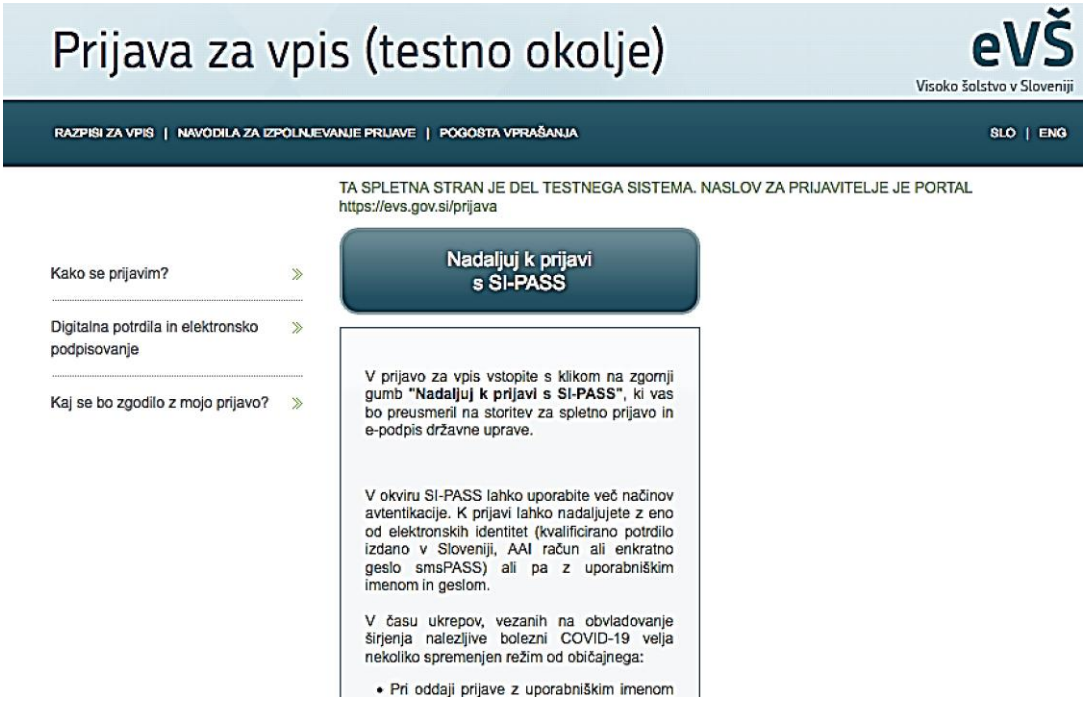


Figure 5: Preproduction portal at SI-MIZŠ

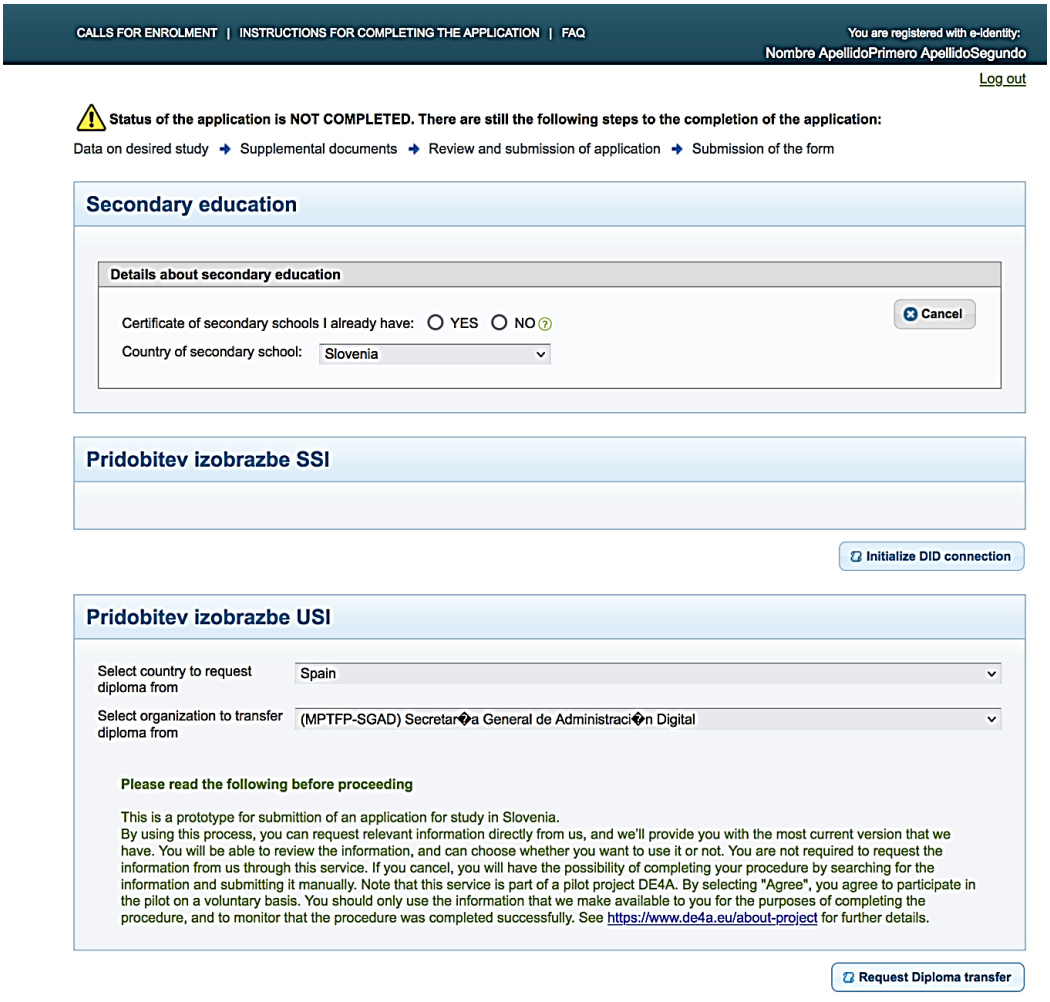


Figure 6: Explicit request at SI-MIZŠ

Jozef Stefan Institute (SI-JSI)

Jozef Stefan Institute is the biggest research institute in Slovenia. As part of the Studying Abroad pilot, it has provided a preproduction service where real foreign students can apply for study grants (see Figure 7). Students coming from countries participating in DE4A can explicitly request to securely retrieve (through the User-Supported Intermediation evidence exchange pattern and DE4A OOP TS) their diploma, large family evidence, or disability evidence from the official repository in the country where they took their undergraduate studies or in the country where they reside (see Figure 8).

For the final running phase, several calls for study grants have been defined, where STEM students from Portugal and Spain who are studying or will study at one of the higher education institutions in Slovenia and conduct their research work at the Institute can apply for a grant. The calls require different combinations of evidence types (higher education diploma, large family evidence, disability evidence) to be presented. Students from Portugal can only apply to the first call because no other evidence than higher education diploma is available for them. Details on how to use the services are provided in the Studying Abroad pilot microsite [5].

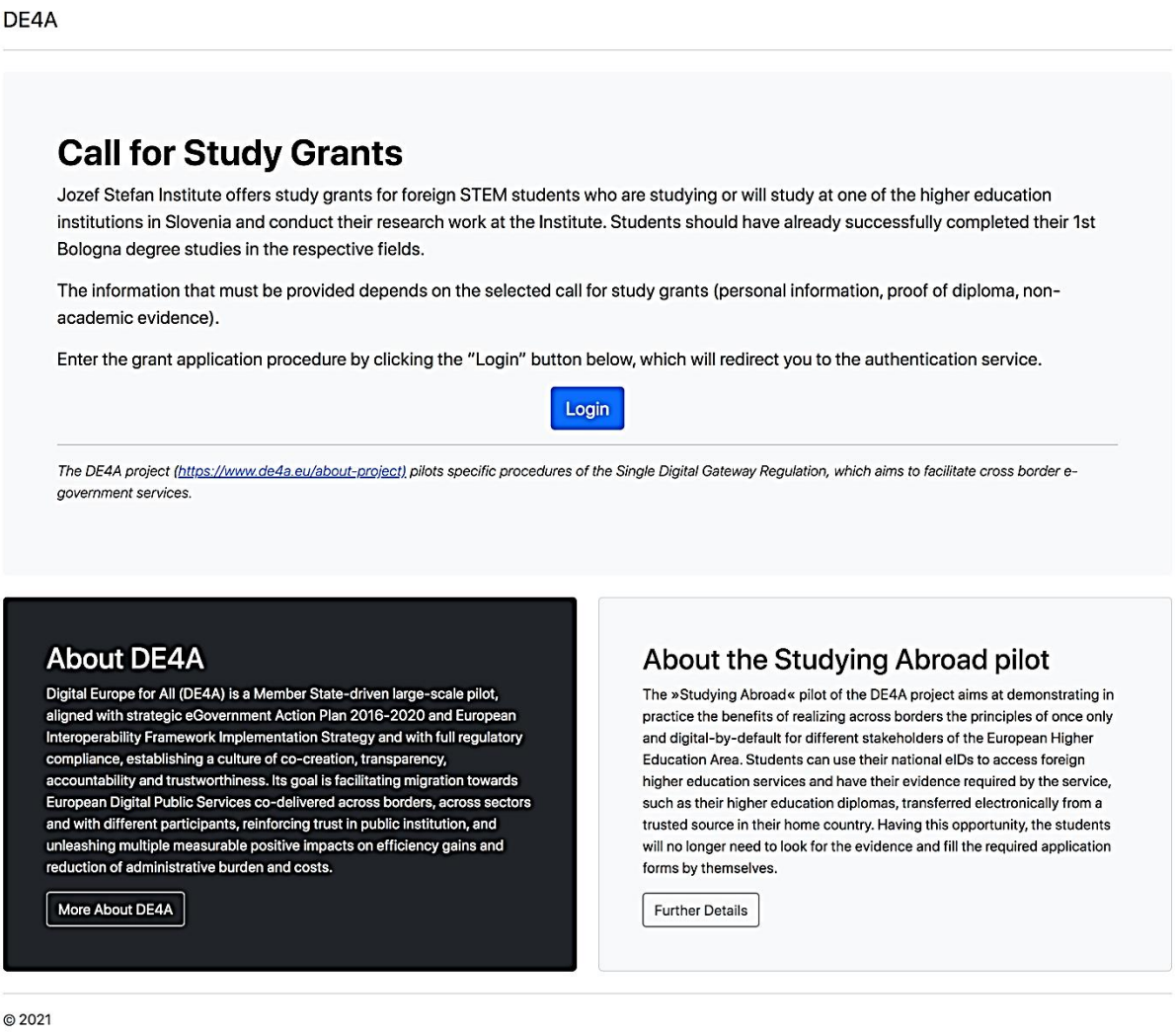


Figure 7: Grant application service at JSI

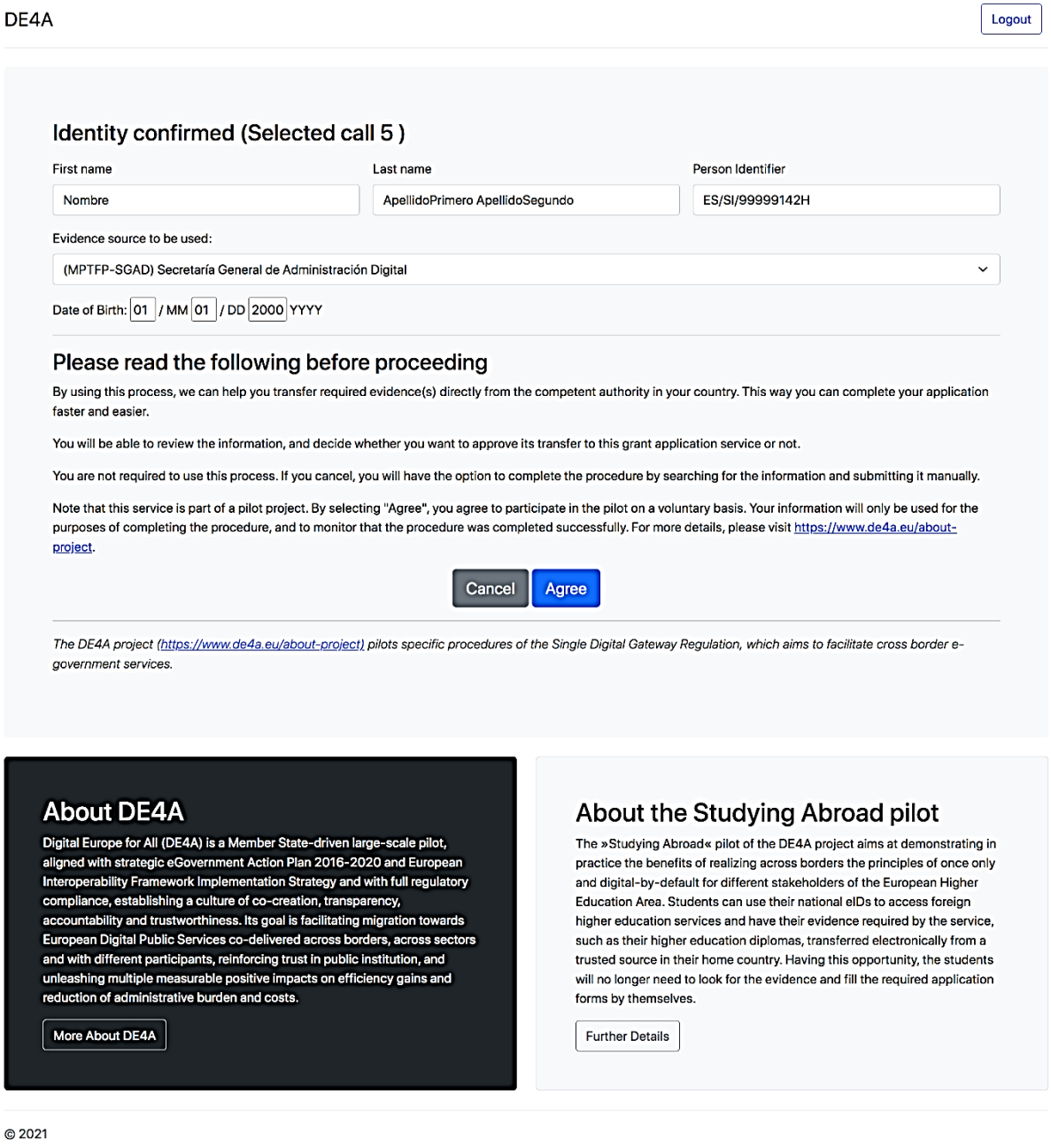


Figure 8: Explicit request at JSI

2.1.3 Data owners

Table 2 gives an overview of all data owners in the pilot. Three organisations in Portugal, Slovenia, and Spain have customized their Evidence portals and integrated them either with DE4A OOTS or with the SSI Authority agent and EBSI. Three DOs (ES-SGAD and INESC-ID have the same DO for UC#1 and UC#2) and three Verifiable Credential (VC) Issuers have been launched. MIZŠ Issuer was replaced by a dedicated Issuer at the University of Maribor due to lack of resources.

Table 2: Data owners (DO) in the Studying Abroad pilot

Data Owner	Use case	URL	Provided evidence	Status
ES-SGAD	UC#1	N/A[2]	Higher education diploma (real), Secondary education diploma (test)	Launched, piloting completed
	UC#2	N/A[3]	Higher education diploma (real), Large family (test), Disability (test)	Launched, piloting completed
	UC#3	https://pre-as4gw-dt-de4a.redsara.es/de4a-pid-owner/verifiableCredentials.xhtml	Higher education diploma (real)	Launched, piloting completed
PT-INESC-ID	UC#1	N/A[4]	Higher education diploma (real)	Launched, piloting completed
	UC#2	N/A[5]	Higher education diploma (real)	Launched, piloting completed
	UC#3	https://de4a-portal.gsd.inesc-id.pt:8443/	Higher education diploma (real)	Launched, piloting completed
SI-MIZŠ	UC#1	N/A[6]	Higher education diploma (real)	Launched, piloting completed
	UC#3	N/A[7]	Higher education diploma (real)	/

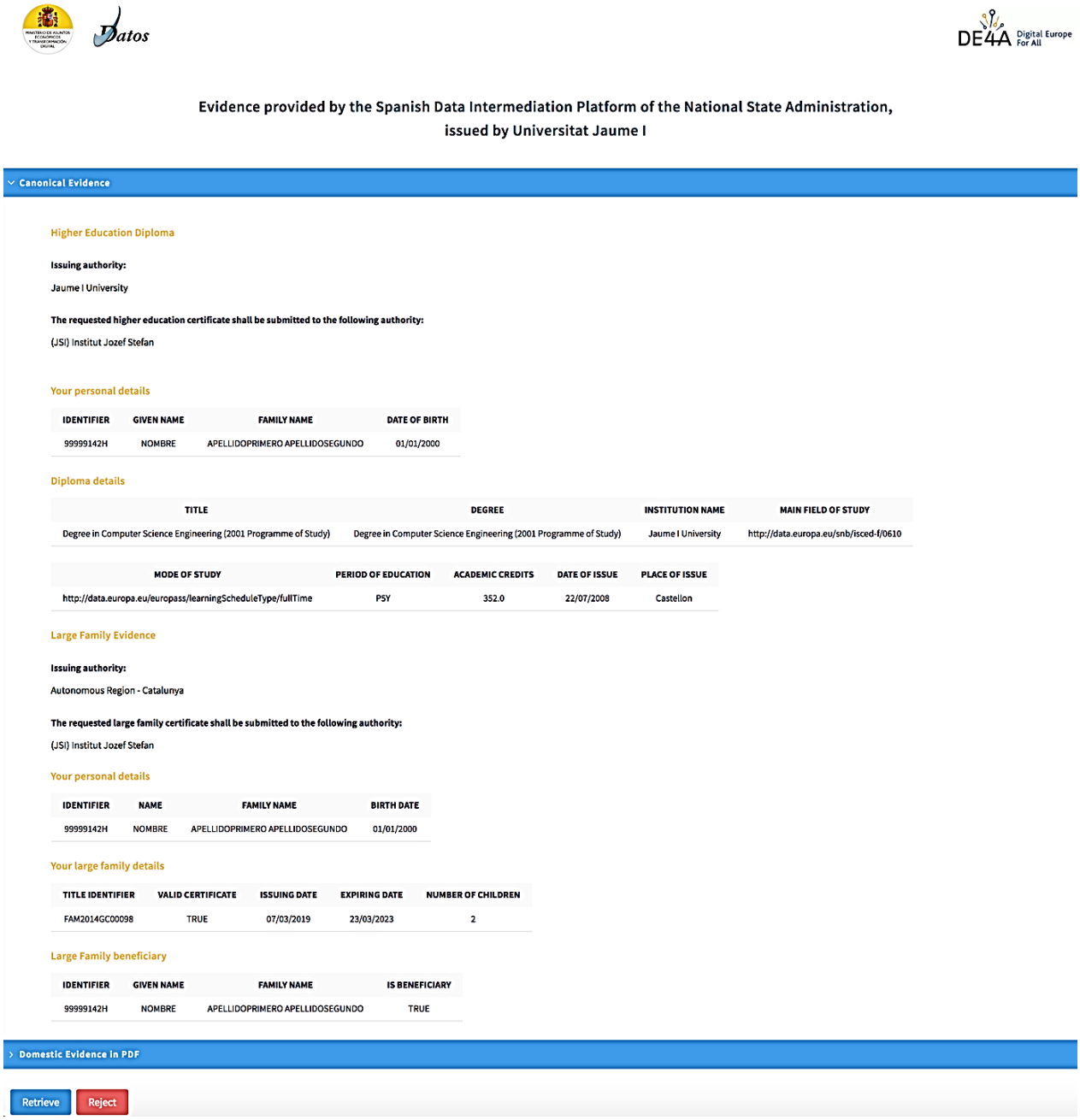
Walkthroughs and guidelines for the launched DOs are available at https://www.de4a.eu/studyingabroadpilot.

SGAD (ES-SGAD)

Students from Universitat Jaume I can request their higher education diploma evidence to be retrieved from the Spanish central data intermediation platform, where specific data services developed by Universitat Jaume I offer the necessary additional data to complete the already available Ministry of Education data, fulfilling the requirements for the canonical evidence issuance. The Spanish central data intermediation platform also provides secondary education diploma evidence, large family evidence, and disability evidence, but only test data for these evidence types was used for piloting. The following figures show starting pages for the USI (Figure 9) and VC (Figure 11) patterns, as well as the Preview functionality (Figure 10).

[2] UJI DO for UC#1 does not enable direct public access, as its evidence is retrieved through the Spanish central data intermediation service.
[3] UJI DO for UC#2 does not enable direct public access, as its evidence is retrieved through the Spanish central data intermediation service.
[4] AMA DO does not enable direct public access.
[5] AMA DO does not enable direct public access.
[6] SI-MIZŠ DO for UC#1 does not enable direct public access, as its evidence is retrieved by the Preview component at the Ministry of Public Administration of the Republic of Slovenia through a national OOP system Tray.
[7] The VC Issuer for Slovenia was implemented and launched for the pilot purposes at the University of Maribor.

Figure 9: Data intermediation platform at SGAD



Evidence provided by the Spanish Data Intermediation Platform of the National State Administration, issued by Universitat Jaume I

Canonical Evidence

Higher Education Diploma

Issuing authority:

Jaume I University

The requested higher education certificate shall be submitted to the following authority:

(JSI) Institut Jozef Stefan

Your personal details

IDENTIFIER	GIVEN NAME	FAMILY NAME	DATE OF BIRTH
99999142H	NOMBRE	APELLIDOPRIMERO APELLIDOSEGUNDO	01/01/2000

Diploma details

TITLE	DEGREE	INSTITUTION NAME	MAIN FIELD OF STUDY
Degree in Computer Science Engineering (2001 Programme of Study)	Degree in Computer Science Engineering (2001 Programme of Study)	Jaume I University	http://data.europa.eu/snb/isced-f/0610

MODE OF STUDY	PERIOD OF EDUCATION	ACADEMIC CREDITS	DATE OF ISSUE	PLACE OF ISSUE
http://data.europa.eu/europass/learningScheduleType/fullTime	P5Y	352.0	22/07/2008	Castellon

Large Family Evidence

Issuing authority:

Autonomous Region - Catalunya

The requested large family certificate shall be submitted to the following authority:

(JSI) Institut Jozef Stefan

Your personal details

IDENTIFIER	NAME	FAMILY NAME	BIRTH DATE
99999142H	NOMBRE	APELLIDOPRIMERO APELLIDOSEGUNDO	01/01/2000

Your large family details

TITLE IDENTIFIER	VALID CERTIFICATE	ISSUING DATE	EXPIRING DATE	NUMBER OF CHILDREN
FAM2014GC00098	TRUE	07/03/2019	23/03/2023	2

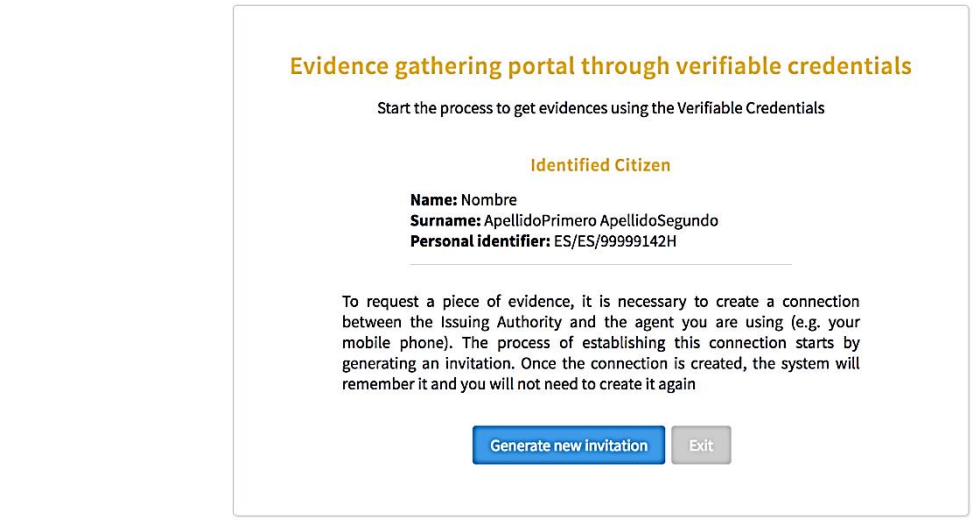
Large Family beneficiary

IDENTIFIER	GIVEN NAME	FAMILY NAME	IS BENEFICIARY
99999142H	NOMBRE	APELLIDOPRIMERO APELLIDOSEGUNDO	TRUE

Domestic Evidence in PDF

Retrieve Reject

Figure 10: Preview at Spanish DO



Co-financed by the European Union
Connecting Europe Facility

Figure 11: ES VC Issuer

INESC-ID (PT-INESC-ID)

Graduates from Instituto Superior Técnico can request their diploma evidence to be retrieved from the school's information system Fenix. This involves using the DO, implemented in part by AMA and in part by INESC-ID for UC#1 and UC#2.

Students can also use the portal to obtain a diploma in the format of a VC (UC#3). For that purpose, they must authenticate in the portal and request the diploma, which is granted if the student concluded the studies. Details on how to use the service to obtain a diploma are provided on the Studying Abroad pilot microsite [5]. Figure 12 shows the Preview functionality of Data Owner for Use Cases 1 and 2.

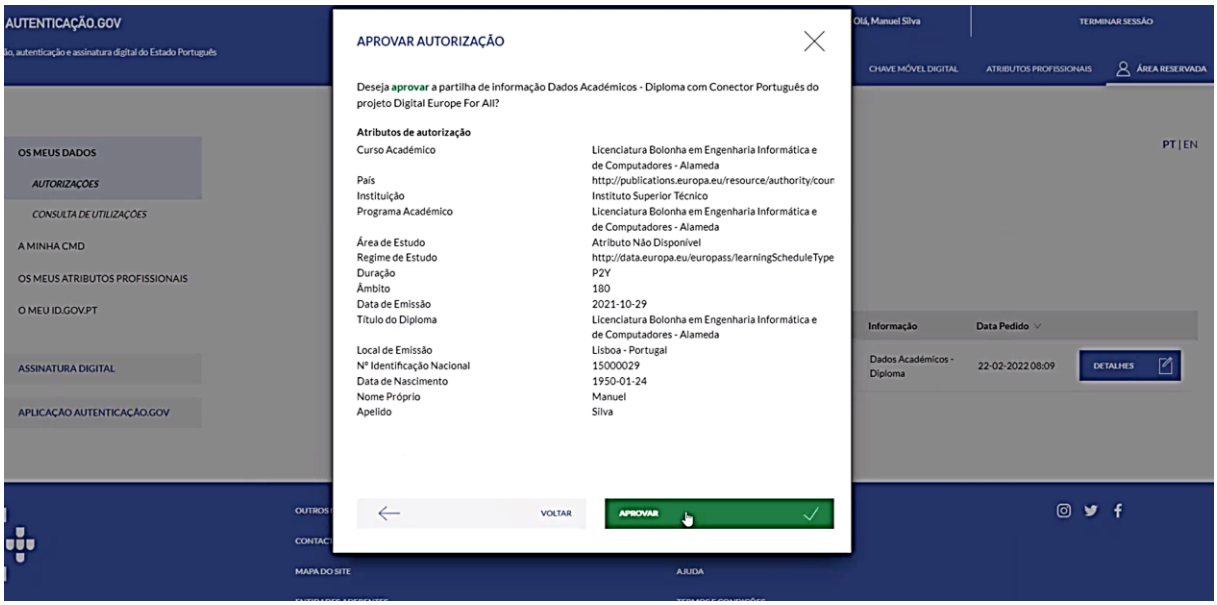
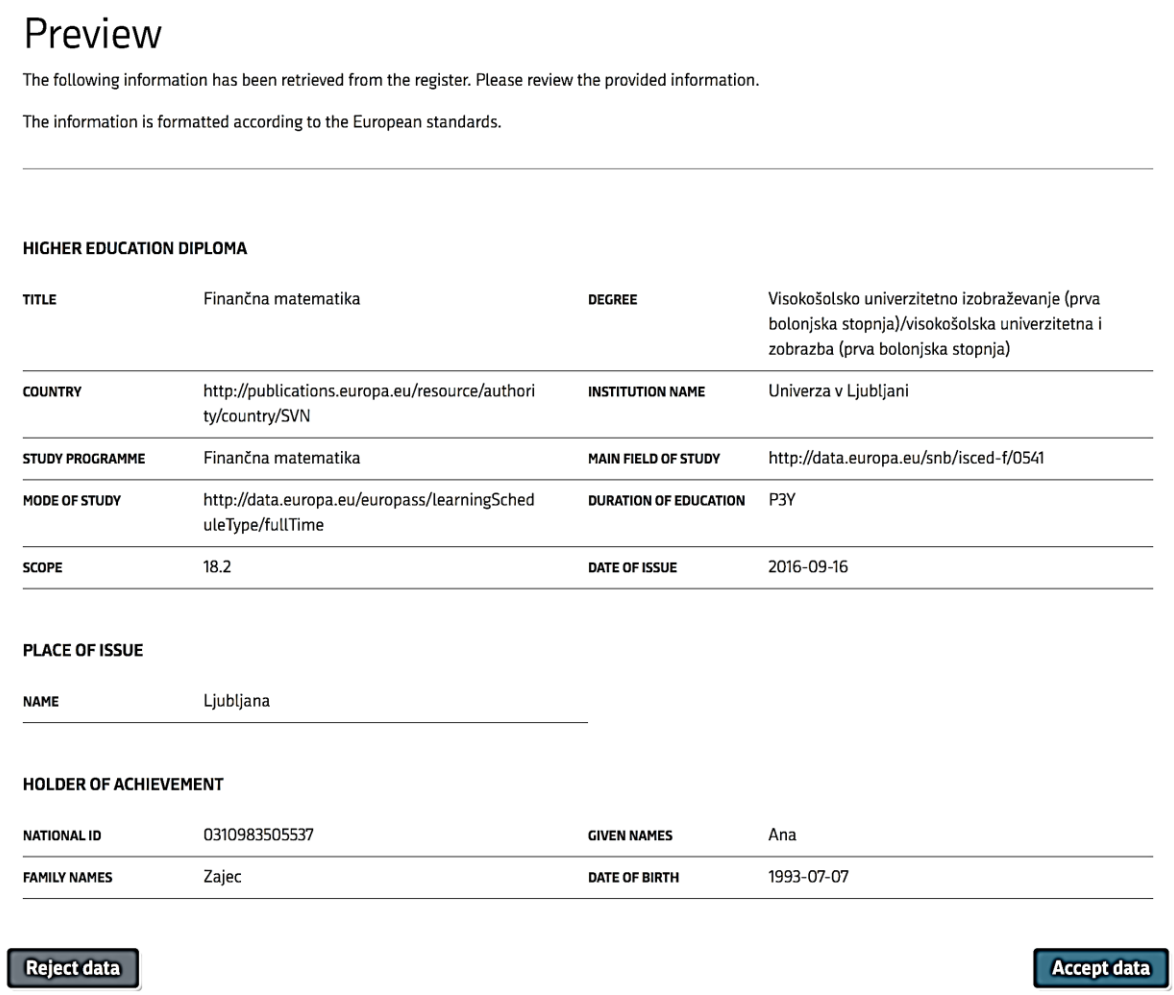


Figure 12: Preview at Portuguese DO

Ministry of Education, Science and Sport of the Republic of Slovenia (SI-MIZŠ)

The eVŠ system at the Ministry of Education, Science, and Sport of the Republic of Slovenia contains information about all students studying or who have studied at one of the Slovenian higher education institutions. For the pilot running phase, the eVŠ service in preproduction has been integrated through the Slovenian national OOP system Tray and the central Preview component into the DE4A OOP technical system (see Figure 13 for the Preview page). In the final pilot iteration, this service provides real data (higher education degree diplomas) only for preselected students who signed a GDPR form and were using real eIDs.

Due to lack of resources at the SI-MIZŠ issuer, the University of Maribor enabled a selected group of its students to download real diplomas in the form of verifiable credentials to their mobile phones through a reference implementation of the VC issuer.



Preview

The following information has been retrieved from the register. Please review the provided information.

The information is formatted according to the European standards.

HIGHER EDUCATION DIPLOMA

TITLE	Finančna matematika	**DEGREE**	Visokošolsko univerzitetno izobraževanje (prva bolonjska stopnja)/visokošolska univerzitetna i zobrazba (prva bolonjska stopnja)
COUNTRY	http://publications.europa.eu/resource/authority/country/SVN	**INSTITUTION NAME**	Univerza v Ljubljani
STUDY PROGRAMME	Finančna matematika	**MAIN FIELD OF STUDY**	http://data.europa.eu/snb/isced-f/0541
MODE OF STUDY	http://data.europa.eu/europass/learningScheduleType/fullTime	**DURATION OF EDUCATION**	P3Y
SCOPE	18.2	**DATE OF ISSUE**	2016-09-16

PLACE OF ISSUE

NAME	Ljubljana

HOLDER OF ACHIEVEMENT

NATIONAL ID	0310983505537	**GIVEN NAMES**	Ana
FAMILY NAMES	Zajec	**DATE OF BIRTH**	1993-07-07

Reject data

Accept data

The DE4A project (https://www.de4a.eu/about-project) has been funded by the European Commission. This project pilots specific procedures of the Single Digital Gateway Regulation - Article 14 of the SDGR specifies the requirement for an explicit request. Copyright 2022

Figure 13: Preview at Slovenian DO

2.2 Strategy followed to avoid implementation delays

The pilot was designed to have a wide variety of services to be piloted in different MS and under the responsibility of different institutions. The pilot also heavily depended on the results of other DE4A work packages, in particular WP5 and WP3. To prevent pilot delays and facilitate the integration of the services with the DE4A OOP Technical System several strategies have been put into place:

Integration of DEs and DOs using the playground

Testing was performed in the playground to facilitate the integration of DEs and DOs by having a tool available to validate the integration of the components by replicating the behaviour of the real components (Connectors acting as DR and DT, mocked DE and mocked DO) and providing processes to accomplish the different test cases allowing to test the integration of endpoints with DE4A Connector and to test exchange of cross-border messages against mocks even before counterpart endpoints are ready. A new playground was enabled for the final iteration supporting the updates to mocked DE and mocked DO for the USI evidence exchange pattern (SMP/IAL-enabled dynamic discovery of services, improved user redirection, multi-evidences), also supporting the new and updated canonical evidence types.

Use of DE4A Connectors in preproduction

Until the piloting environments were in place and production certificates were also available (these were also updated once between pilot iterations), common components such as the DE4A Connector were implemented in the preproduction or testing environment to enable the various setups, configurations, and tests to be as close as possible to the real final infrastructure. MS were free to select whichever environment they seemed suitable for the deployment of the central components (national SMPs, second iteration connectors, and corresponding production certificates) and piloting.

Use of eIDAS nodes in preproduction because of non-notified eID scheme in Slovenia

As of the beginning of 2023, Slovenia had only pre-notified its identification scheme. To ensure interoperability with the still non-notified eIDs from Slovenia, the existing pre-production eIDAS nodes from Portugal, Slovenia, and Spain were agreed to be used to authenticate Slovenian users to the pilots' higher education procedures.

Issuance of verifiable credentials for Slovenian students at the University of Maribor for UC#3

The Ministry of Education, Science and Sport of the Republic of Slovenia has not implemented an issuer of the diploma evidence in the form of verifiable credentials due to an ongoing lack of resources. To enable the participation of Slovenian students, the University of Maribor has issued verifiable credentials to some of its students using a reference implementation of the VC issuer developed in WP5.

Use of simulated procedures and the procedures in preproduction in some cases

Given the current limitations in the participating MS in offering study grants to foreign EU students (UC#2), a service has been developed simulating the whole application process. Although real students applied for the service, their applications were discarded after submission, or the supervised students were instructed not to submit the applications in the final step. The applications were also discarded for the piloted procedures in preproduction in Slovenia for UC#1 and UC#3 and the simulated procedures in Portugal for UC#1 and UC#3.

Whitelisting of test users when the official calls are closed

Some of the piloted procedures that exist only in production, such as pre-enrolment to higher education in Spain, are available for a limited time each year. To enable testing of these procedures outside the official application periods, students have to submit their communication details before using the service to be allowed by a university for testing. These applications were submitted in special calls and discarded by the university after submission, or the supervised students were instructed not to submit the applications in the final step.

Use of test credentials and test evidence

Most Portuguese students (about 80%) and all Spanish students used test eIDs. The main problem was that students typically don't have their eIDAS-based authentication means activated and/or don't remember the second authentication factor (PIN). One of the barriers was also eIDAS authentication at MIZŠ in Slovenia, which requires additional, one-time registration with the central authentication systems SI-PASS when using real eIDs. Most Portuguese students (about 80%) also used test evidence. Students from Spain used real academic data but anonymized and bound to the personal data of a test credential. Despite test credentials being used the gathered data was therefore still production-relevant for the Spanish data provider. Some (around 60%) of the Slovenian students had to use test eIDs and test data in UC#1 because of problems with a preproduction central authentication system in Slovenia over which DE4A partners had no control.

Summary of the participants' information in the wiki

Due to numerous technical issues encountered during the Connectathons, caused by the inconsistencies of the participants' and endpoints' data in the connectors and SMPs in the test,

preproduction, and production environments, a wiki page has been created to provide an overview of the pilot participants' information[8].

Monitoring and prompt reaction to issues

Pilot activities and status were closely monitored and discussed at weekly pilot meetings, pilot leader meetings, Technical Working Group meetings, and connectathons, as well as bi-weekly Executive Board meetings. Between meetings, a dedicated Slack channel facilitated interaction among pilot partners and the WP5 working package and enabled immediate reaction to any issues that occurred.

2.3 Achieved cross-border interoperability status

This section gives an overview of all DE-DO and Issuer-Verifier combinations planned for the final pilot phase and their cross-border interoperability status at the end of the final iteration. Interoperability status is described below for each use case and summarised in several tables.

The status colour scheme for the upcoming tables is as follows:

Launched	Replaced	Not planned

Launched: The combination has been officially launched for piloting with real users.

Replaced: The combination involves another service that was not initially planned.

Not planned: The combination of the DE and DO is not planned for cross-border testing.

2.3.1 Application to higher education (UC#1)

This service provides a platform for students to apply for admission to higher education institutions in another country, specifically to bachelor's degree studies (1st Bologna degree) in Portugal and Slovenia, and Master's Degree studies (2nd Bologna degree) in Portugal, Slovenia, and Spain. The service largely corresponds to the procedure 'Submitting an initial application for admission to public tertiary education institution' of the 'Studying' Life Event in the Single Digital Gateway Regulation (SDGR)[4][5].

The use case was designed for students to use their national eIDs to access the service and explicitly request the use of the DE4A technical system to have their secondary or higher education diploma evidence required by the service transferred electronically from a trusted source in their home country, satisfying applicable provisions of the SDGR and the GDPR. This way, students no longer have to manually search for evidence and fill in the necessary application forms by themselves. The evidence is previewed at the source after successful record matching, i.e. at the Data Owners' evidence portals where students are redirected and need to (re-)authenticate through eIDAS (USI pattern).

Table 3 shows the achieved cross-border interoperability status between Data Owners (columns) and partners providing this service (rows). ES-UJI only enabled enrolment in master's degree Studies, because regional governments are responsible for enrolment in Bachelor's Degree Studies in Spain. In comparison to the first iteration, an additional combination was piloted (SI-MIZŠ DE – PT-INESC-ID DO) and another one was launched (PT-INESC-ID DE – SI-MIZŠ DO).

Slovenian students used real and test data when piloting Spanish and Portuguese services (combinations ES-UJI – SI-MIZŠ and PT-INESC-ID – SI-MIZŠ). Portuguese students were using test evidence when testing the combinations ES-UJI – PT-INESC-ID and SI-MIZŠ – PT-INESC-ID. Spanish students were using test credentials and anonymized real evidence when testing the services (PT-INESC-ID – ES-SGAD, SI-MIZŠ – ES-SGAD). One of the reasons for using PT and ES test eIDs with the

[8] https://wiki.de4a.eu/index.php/Useful_information_on_pilots_and_participants

MIZŠ services was additional mandatory registration at the central authentication system in Slovenia when using real eIDs[9].

Table 3: Cross-border interoperability status in Use case 1

		Data Owners		
		ES-SGAD	PT-INESC-ID	SI-MIZŠ
Data Evaluators	ES -UJI			
	PT-INESC-ID			
	SI-MIZŠ			

2.3.2 Application for a study grant (UC#2)

The second service allows students to apply for a study grant abroad. This service largely corresponds to the procedure 'Applying for a tertiary education study financing, such as study grants and loans from a public body or institution' of the 'Studying' Life Event in the Single Digital Gateway Regulation (SDGR) [5].

The service helps applicants to explicitly request that their evidence (composed of multiple evidence items including the diploma for the 1st Bologna degree, large family evidence, and disability evidence) is automatically sent to the procedure portal from a trusted source in their home country or countries where they previously studied. Students retain full control over which evidence is sent across borders and which is not, by explicitly agreeing to the transfer of evidence. The evidence is previewed at the source after successful record matching, i.e. at Data Owners where students are redirected and need to (re-)authenticate (USI pattern).

The following table shows the cross-border interoperability status between data owners (columns) and partners deploying this service (rows) at the end of the final iteration. Although PT-INESC-ID is not officially involved in UC#2, its DO for UC#1 was used for piloting in the final iteration, as higher education diplomas were used by both services. Portuguese students did not pilot a multi-evidence case, i.e. no large family and disability evidence was available from Portugal.

Portuguese students were using real and test diploma evidence and Spanish students real anonymized diplomas when testing the service (combinations SI-JSI – ES-SGAD, SI-JSI– PT-INESC-ID). All Spanish students used the test large family and disability evidence.

Table 4: Cross-border interoperability status in Use case 2

		Data Owners	
		ES-SGAD	PT-INESC-ID
Data Evaluators	SI-JSI		

2.3.3 Diploma recognition (UC#3)

The third set of services focuses on diploma recognition in another country to facilitate the use of such information by the government and other sectors. The services implement the Self-Sovereign Identity approach. Students can get their diplomas in the form of Verifiable Credentials from trusted data sources, such as universities where they have previously studied or Ministries of Education, and store

[9] This process involved two asynchronous steps with email sending which was inconvenient for piloting the whole procedure flow in a single session.

them in digital wallets on their mobile phones. In another Member State, they can then present these Verifiable Credentials in the form of a Verifiable Presentation (VP) to a competent authority and request their diplomas to be recognized in that country.

Table 5 shows the cross-border interoperability status between issuers of Verifiable Credentials (columns) and partners verifying Verifiable Presentations (rows) at the end of the final iteration. In the final iteration, all issuers and verifiers used an updated Authority Agent and simplified the flow to reduce the number of student interactions with the services. Due to lack of resources at the SI-MIZŠ Issuer, the University of Maribor enabled a selected group of its students to download real diplomas in the form of verifiable credentials to their mobile phones through a reference implementation of the VC issuer, developed at the university. In comparison to the first iteration, two additional combinations were launched (SI-MIZŠ Verifier – ES-SGAD Issuer and SI-MIZŠ Verifier – PT-INESC-ID Issuer).

Slovenian students used real data when piloting a Portuguese verifier (combination PT-INESC-ID – SI-MIZŠ). Spanish students used real anonymized data and Portuguese students used real and test evidence when testing the services (combinations PT-INESC-ID – ES-SGAD, SI-MIZŠ – ES-SGAD, SI-MIZŠ – PT-INESC-ID) due to various reasons.

Table 5: Cross-border interoperability status in Use case 3

		Issuers		
		ES-SGAD	PT-INESC-ID	SI-MIZŠ
Verifiers	PT-INESC-ID			
	SI-MIZŠ			

2.4 Updates in metrics

Deliverable D4.2 [2] defined quantitative and qualitative metrics for 11 success criteria and 5 pilot goals, as well as the sources for collecting the required data (competent authorities, Member States, and students). An additional questionnaire on the DE4A central components and the testing procedure has been introduced in D4.3 [3].

Compared to D4.2 and D4.3, there were no changes in the metrics in the second iteration. Only an online questionnaire for students was revised to obtain more detailed information on specific issues, e.g. parts of the procedures that are not clear or simple enough, and interviews with university administration staff were conducted. The collection of service logs was also improved in the final iteration (six services compared to two from the first iteration).

3 Pilot success criteria related to pilot dimensions

In this chapter, the pilot goals and success criteria are first reviewed, and then take-up by pilot stakeholders (students, administration staff at Data evaluators and Data consumers, and Member States), verified benefits, and lessons learnt in the final iteration are described. The success criteria results are summarised in relation to the metrics, and for each metric, a target value is provided. The chapter ends with a description of how each of the DE4A technical common criteria was met by the pilot in the final iteration.

3.1 Goals and pilot success criteria

The Studying Abroad pilot's main objective is to facilitate the mobility of European students across the European Higher Education Area, based on paperless cross-border procedures that support the Once-Only Principle and the use of electronic identities. The goals described in Table 6 were first described in D4.1 [1] and then refined in D4.2 [2].

Table 6: Studying Abroad pilot goals

Actor	ID	Goal
Public authorities	A	Reduce administrative burdens through the improvement of the quality of student data and data processing effort within the eProcedures by re-using data from authentic sources
	B	Improve the processing effort of evidence provision
Students	C	Satisfaction of the students and effort and time reduction
Project	D	Evaluate the OOP components supporting the cross-border information flow: ▸ Assess the technical impact on national services already in place ▸ Evaluate connections of national systems to the DE4A OOP TS ▸ Evaluate deployment of DE4A OOP TS ▸ Define (functional) requirements for the OOP infrastructure, different functional service patterns, and semantic interoperability as well as technical requirements for national services that must connect to the OOP-infrastructure ▸ Promote the OOP within the Member States (higher education institutions and public administration).
	E	Evaluate the use of the Self-Sovereign Identities approach in higher education, based on an innovative vendor-independent blockchain framework
	F	Evaluate whether the once-only solutions designed to the SA-specific challenges have proven adequate in piloting the SA eProcedures: ▸ Usability of harmonised higher education evidence model ▸ Usability and correct implementation and use of Explicit Request and Preview ▸ Record matching on natural persons in the context of direct interaction of the user with the evidence providing authority

The next tables display how the pilot goals are decomposed into success criteria that were used for the SA pilot, and map these criteria to:

- the Common Pilot Principles (Use, Value, Learning and Adoption[10])
- the Technical Common Criteria (Openness, Transparency, Reusability, Technical Neutrality and Data Portability, User Centricity, Inclusion and accessibility, Security & Privacy, Administrative simplification, Effectiveness & Efficiency).

Success Criteria for Public Authorities

The first criteria are relevant for Data Evaluators and Data Owners. Both the criteria and consequently the metrics relate more to Value, although other principles are also relevant and are addressed in Section 3.2.2.

Table 7: Criteria for Data Evaluators

ID	Criterion	Technical Common Criteria	Principles
Pilot goal A: Reduce administrative burdens through the improvement of the quality of student data and data processing time within the eProcedures by re-using data from authentic sources			
A1	The DE recognizes the student data as of higher quality (e.g. student data is guaranteed to be valid, is more reliable, is in structured electronic format, is more meaningful, is more complete).	Reusability, Transparency, Effectiveness & Efficiency, Administrative Simplification	U, L, **V**, A
A2	The DE recognizes the student data as easier to process.	Reusability, Transparency, Effectiveness & Efficiency, Administrative Simplification	U, L, **V**, A

Table 8: Criteria for Data Owners

ID	Criterion	Technical Common Criteria	Principles
Pilot goal B: Improve the processing time of evidence provision			
B1	The DO recognizes the requests for evidence as easier to process.	Reusability, Transparency, Effectiveness & Efficiency, Administrative Simplification	U, L, **V**, A

Success Criteria for Students Applying for a Service

The criterion for students and consequently the metrics relate more to Use, although other principles are also relevant. All Use related results (related to success criterion C1 and goal C) are presented in Section 3.2.1.

[10] These principles are addressed in Section 3.2, re-organized under the different perspectives of pilot users (Students and Public administration users). Learning and Adoption are closely linked at the end of the project.

Table 9: Criteria for students

ID	Criterion	Technical Common Criteria	Principles
Pilot goal C: Satisfaction of the students and effort and time reduction			
C1	The user acknowledges the procedure for applying for a service as efficient, effective and secure (e.g. the procedure requires acceptable effort, the procedure is not complex, is reliable, is secure, is established with simple and effective communication, has no language barriers, the user experiences no errors during the eProcedure, control given when managing his/her evidence).	Reusability, Effectiveness & Efficiency, Administrative Simplification, Transparency, Security and Privacy	**U**, L, V, A

Success Criteria for Pilot Technical Goals

These criteria for the pilot technical goals and consequently the metrics relate more to Adoption and Learning, although other principles are also relevant. All Adoption and Learning related results are available in Section 3.2.3 including metrics related to success criteria F.x and goal F given their general learning nature for MS (metrics related to success criteria D.X and E.X and goals D and F are included in Section 3.2.2 as perspectives from public administration users are included there).

Table 10: Criteria for evaluation of common components

ID	Criterion	Technical Common Criteria	Principles
Pilot goal D: Evaluate the OOP components supporting the cross-border information flow: ▸ Assess the technical impact on national services already in place ▸ Evaluate connections of national systems to the DE4A OOP TS ▸ Evaluate deployment of DE4A OOP TS			
D1	The DO believes the cost and effort of customizing the Evidence portal and data service and integrating them to the DE4A Connector will eventually be outweighed by the benefits.	Openness, Technological Neutrality and Data Portability	V, **A**
D2	The DE believes the cost and effort of customizing the eProcedure portal and integrating them to the DE4A Connector will eventually be outweighed by the benefits.	Openness, Technological Neutrality and Data Portability	V, **A**
D3	The participating Member State believes the cost and effort of setting up and deploying the AS4 gateway, the SMP and the DE4A Connector will eventually be outweighed by the benefits.	Openness, Technological Neutrality and Data Portability	U, **L**
Pilot goal E: Evaluate the use of the Self-Sovereign Identities approach in higher education, based on an innovative vendor-independent blockchain framework			
E1	The DO believes the cost and effort of integrating the SSI Authority agent will eventually be outweighed by the benefits.	Openness, Technological Neutrality and Data Portability, User Centricity	V, **A**
E2	The DE believes the cost and effort of integrating the SSI Authority agent will eventually be outweighed by the benefits.	Openness, Technological Neutrality and Data	V, **A**

		Portability, User Centricity	
Pilot goal F: Evaluate whether the once-only solutions designed for the SA-specific challenges have proven adequate in piloting the SA eProcedures			
F1	Real education services are developed, successfully connected, and piloted as fully online cross-border procedures to the DE4A interoperability infrastructure by the respective pilot partners	Openness, Technological Neutrality and Data Portability	U, **A**
F2	The Higher Education Evidence Models have proven adequate for the cross-border exchange of information on students for the SA eProcedures.	Openness, Technological Neutrality and Data Portability, Reusability	U, **L**, V
F3	The Explicit Request and Preview requirements as specified in the SDGR have proven suitable for higher education eProcedures.	Administrative Simplification, User Centricity, Inclusion and Accessibility	U, **L**
F4	The mechanisms for record matching at the DO have proven adequate for the SA eProcedures.	Administrative Simplicity, Effectiveness & Efficiency	U, **L**

While the rest of this section provides a detailed overview of the collected metrics and their processing in success criteria, the following table gives a summary of the quantitative results:

Table 11: Overview of the metric results

Goal	A	B	C	D	E	F
Number of success criteria	2	1	1	3	2	4
Number of metrics	2	1	4	6	4	4
Number of scale-type metrics with targets	2	1	4	3	2	1
Percentage of scale-type metrics below target	0%	0%	0%	33%	0%	0%
Percentage of scale-type metrics fully on/over target	100%	100%	100%	67%	100%	100%
The rounded average number of responses per metric within a goal	4	4	104	3	4	16

3.2 Pilot dimensions

3.2.1 Students

In this subsection, the take-up and value of the pilot services by students and the feedback provided by them in the final pilot run are analysed (see same section in D4.3 [3] for previously collected results from students during the first iteration based on the Minimum Viable Product scope of the pilot).

The results are based on feedback from over 100 students collected via an online questionnaire (see Annex C of D4.2[2]) and the logs of DEs and DOs. As described in more detail in Section 4.2, students were invited to participate in piloting after the services went live and to complete an online questionnaire. Like in the first iteration, they had to belong to participating institutions (University of Maribor, University Jaume I, INESC-ID), as no other universities are integrated with the DE4A OOTS.

3.2.1.1 Use

The number of students accessing the services and providing feedback through the online questionnaire doubled compared to the first iteration and amounted to 104 students: 45 from Spain (43%), 30 from Slovenia (29%), and 29 from Portugal (28%). The use cases UC#1, UC#2, and UC#3 were tested 38 (37%), 28 (27%), and 38 (37%) times respectively. The numbers of students for each service and country are shown in Table 12.

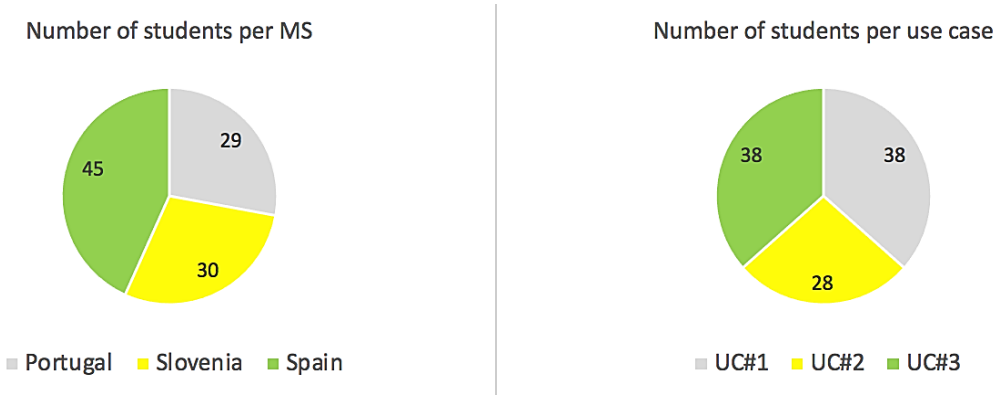


Figure 14: Number of students per MS and use case

Students from Slovenia used real and test data for both UC#1 and UC#3. Students from Portugal also used test and real credentials (citizen cards) and test and real data (few students used real credentials and real data in UC#2 and UC#3, while all students used test data in UC#1). Students from Spain used test credentials and real academic data but anonymized and bound to the personal data of a test credential. All Spanish students used test large family and disability evidence. The main reason for using test eIDs was that students typically don't have their eIDAS-based authentication means activated or can't remember their 2nd authentication factor (i.e. PIN). One of the barriers was also eIDAS authentication in some services (MIZŠ) in Slovenia, which requires additional, one-time registration with the central authentication systems SI-PASS when using real eIDs. This process involved two asynchronous steps with email sending which was inconvenient for piloting the whole procedure flow in a single session.

Table 12: Students and tested services

		Students			
Use case	Service	ES	PT	SI	Total
UC#1	ES-UJI		2	11	13
	PT-INESC-ID	8		7	15
	SI-MIZŠ	5	5		10
UC#2	SI-JSI	20	8		28
UC#3	PT-INESC-ID (Verifier, Issuer)	4	7	10	21
	ES-SGAD Issuer	4			4
	SI-MIZŠ (Verifier)	4	7		11
	SI-UM* (Issuer)[11]			2	2

[11] Instead of the SI-MIZŠ Issuer, selected students from the University of Maribor downloaded their higher education diplomas from a test portal implementation at UM.

3.2.1.2 Value

The students have rated their satisfaction with the completed e-procedures focused on various aspects, such as required effort, clarity of the procedure, or simplicity. Table 13 summarizes the average values of the responses for each aspect and use case (1 = Very dissatisfied, 2 = Dissatisfied, 3 = Neutral, 4 = Satisfied, 5 = Very satisfied) as well as for all use cases together.

Table 13: Satisfaction with completed procedures

Aspect	UC1 (n=38)	UC2 (n=28)	UC3 - Issuer (n=13)	UC3 - Verifier (n=25)	Total
Required effort	3,74	4,18	4,46	4,04	4,02
Clarity of the procedure	3,39	3,75	4,00	3,60	3,62
Simplicity	3,47	3,82	4,00	3,36	3,61
Number of errors and interruptions	2,92	3,68	4,38	3,80	3,52
Language	3,63	3,93	4,31	3,92	3,87
Communication	3,55	3,79	4,00	3,80	3,73
Overall experience	3,37	3,89	4,15	3,88	3,73
Duration of procedure	3,97	4,36	4,69	4,36	4,26
Security and privacy protection	3,89	4,25	4,23	4,12	4,09
Control when managing own education credentials	4,00	4,25	4,38	4,29	4,16

These values are graphically presented in Figure 15 with coloured bars to distinguish results per Use Case.

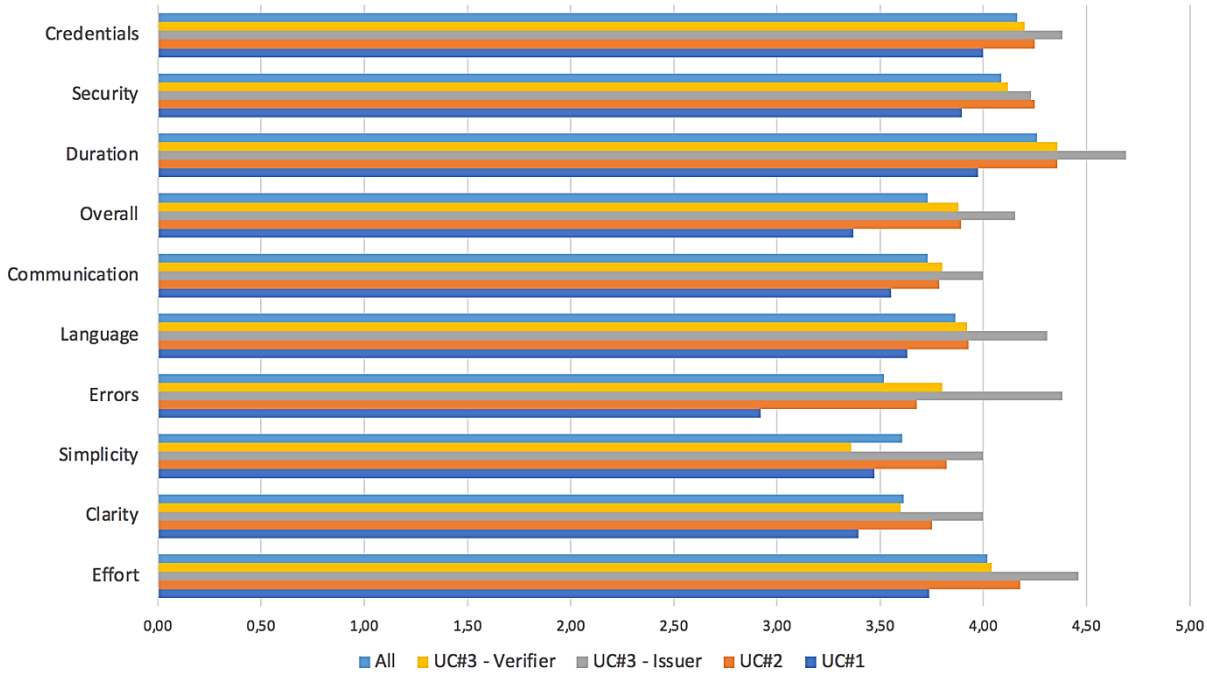


Figure 15: Average satisfaction per aspect and use case

Compared to the first iteration, the students' satisfaction slightly improved for all aspects but three, as presented in Figure 16.

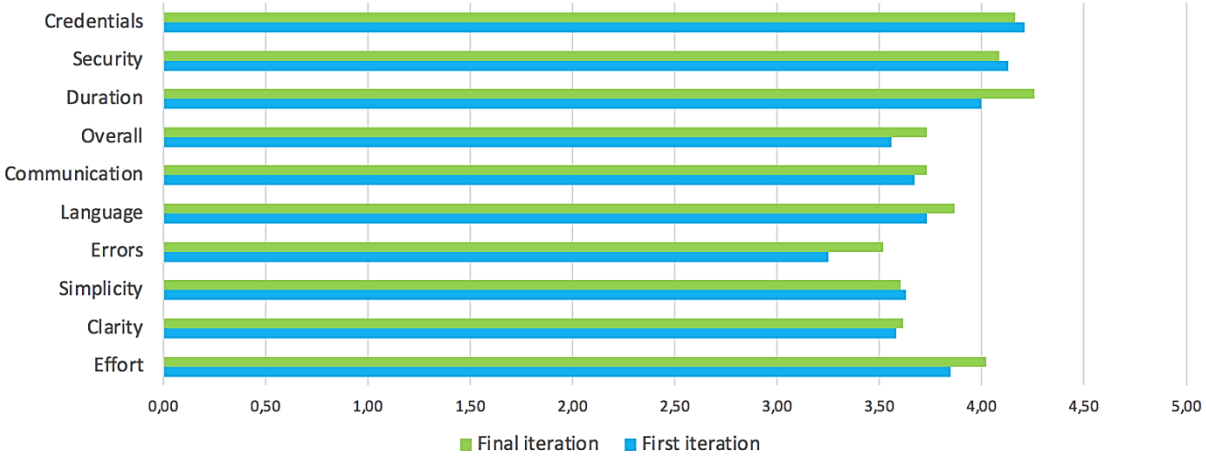


Figure 16: First and final iteration

Figure 17 shows the number of students who were satisfied or dissatisfied, in varying degrees, with each of the described aspects.

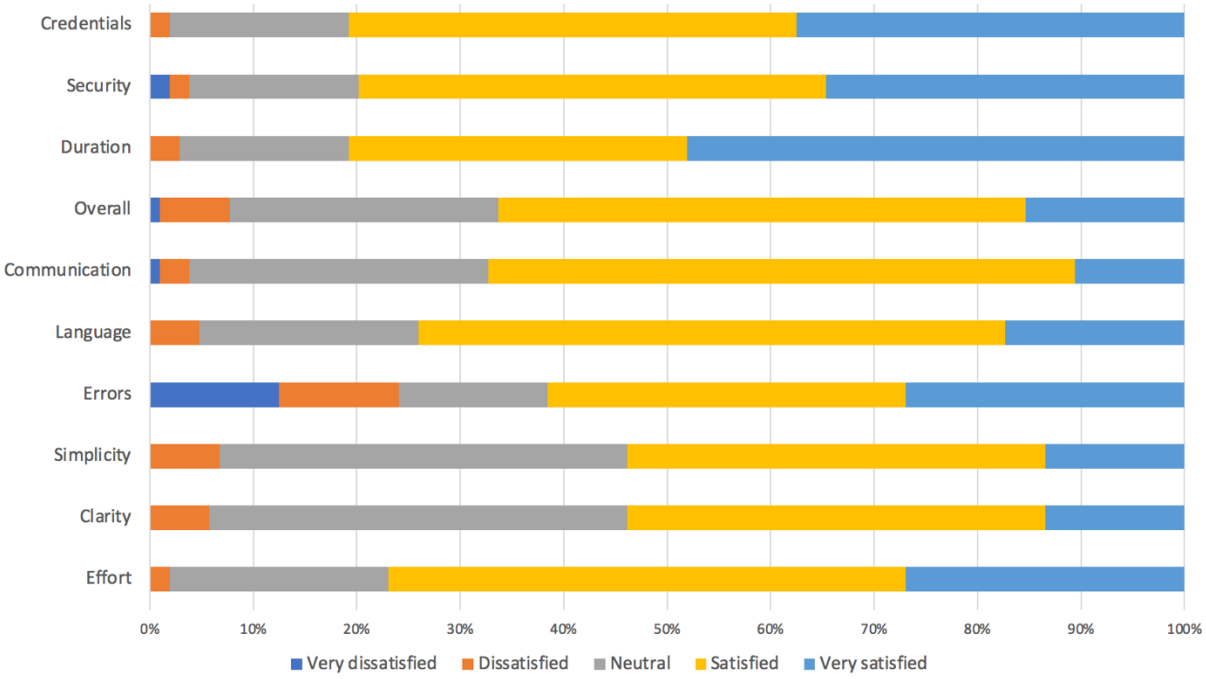


Figure 17: Share of satisfied students per aspect

As shown above, the most highly appreciated aspects of the piloted procedures were the duration of the procedures (4.26), control in managing own credentials (4.16), security and privacy protection (4.09), and required effort (4.02).

The least appreciated was the number of errors and interruptions (3.52). As reported by students, the errors were both internal and external to DE4A. External errors are mainly related to the instability of the preproduction eIDAS environment, which is an external infrastructure to DE4A, and the availability of enrolment calls at participating universities. During the piloting period, there were also connectivity issues between endpoints, common components, and national OOTS from time to time that prevented the use of cross-border services. The clarity and simplicity of the procedures could still be improved, as only 54% of the respondents were satisfied or very satisfied with them. It should be noted here that

the three procedures differ in complexity as they cover different life events in the area of higher education. The procedures also include eIDAS authentication, which can be a complex procedure by itself. The communication and language aspects have slightly improved compared to the first iteration.

The students also commented on other specific functionalities, such as internationalisation, security, Explicit Request, and Preview:

Internationalisation: Services are available in the national language of each service provider and in English. Four students reported incomplete translations and switching between languages.

Security: One of the test services at MIZŠ was not using HTTPS for secure communication.

Explicit Request: The majority of the students who responded to this question (41 students, 39.4%) understood under which conditions they were using the service, or how and from where the evidence would be retrieved. The remaining students provided negative comments (6 students, 5.8%) or did not respond (57 students, 54.8%).

Evidence Preview: The majority of the students who responded to this question (44, 42.3%) were fully informed of what data would be transferred across the border and felt in control of the evidence transfer. The remaining students provided negative comments (3 students, 2.9%) or did not respond (57 students, 54.8%).

Use data from the logs

The logs of the DEs were used to measure the duration of the piloted procedures and to identify potential problems. Table 14 shows the duration in seconds for 6 services in UC#1, UC#2, and UC#3. As the number of logs (n=154) is bigger than the number of students who piloted the services, it should be noted that for ES and SI services not only the service runs of the students who filled in the online questionnaire were considered, but also the logs of other service uses (e.g. additional tests by the pilot partners). For each of the services, the number of logs is given next to the service name and the average and median durations are provided. Median values were also provided to take into account the outliers affecting the average. For ES-UJI (*) the values indicate only the time spent on the specific DE4A evidence retrieval part of the application, not the whole time spent on the procedure. For ES-SGAD (**), the times exclude the eIDAS authentication, and for INESC-ID services (***), the times exclude the initial eIDAS authentication at the portal. The numbers show that DE4A procedures in the higher education domain can be completed in a few minutes.

Table 14: Duration of services

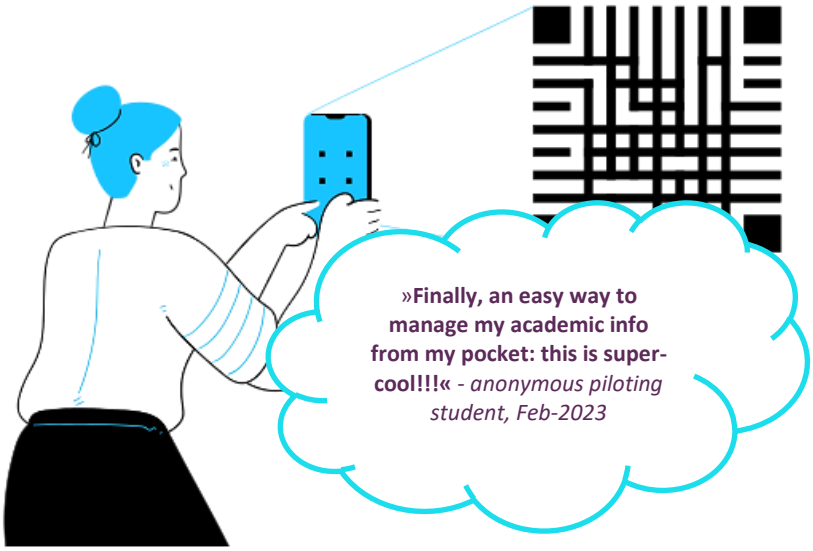
Use case	Service	Average (sec)	Median (sec)
UC#1	ES-UJI (n=55)*	61	44
	INESC-ID (n=8)***	102	87
UC#2	SI-JSI (n=64)	92	65
UC#3	INESC-ID Issuer (n=7)***	86	58
	INESC-ID Verifier (n=12)***	84	60
	ES-SGAD (n=8)**	66	61

3.2.1.3 Success story

With a user-centric evidence exchange students are in control of how they exchange data, while saving time and becoming more (digitally) organized.

From the perspective of the **students**, the piloted DE4A approach with the **VC pattern** brings multiple advantages to them. The VC pattern was piloted only in **one** use case in the study abroad pilot, i.e., **diploma recognition**, which is however connected to the application for studies use case.

To understand the benefits for the students, it should be noted that the new digitalized process for the students involves the usage of their smartphones for gathering and presenting their diploma evidence in a digital form.



The digitalized process brings the following benefits to the students, which were verified by piloting students from 3 different EU countries and their respective institutions, i.e., the University of Maribor, UJI, and IST Lisbon (INESC-ID):

Once the student acquires their diploma on the smartphone, they will have this **digitized form of their diploma 24/7 and for as long as they wish**. They can use it for the diploma recognition process but also for any other official process later on, where the diploma would be needed, as well as for their unofficial activities (e.g., showcasing to family and friends).

The students can be **assured of the trustworthiness** and **integrity** of the evidence collected, as they can see and verify that documents are digitally signed and related to the correct issuing authorities and will therefore be accepted as authentic by providers of different electronic services.

By using this approach, the student can also be **more organized**, while collecting their various possible evidence in a digital format and using them later on when needed. By using this approach, the student also **saves a lot of time**, since from the moment the student has acquired the evidence (e.g., diploma) **once**, they do not have to repeat the acquisition process when having to use other official processes.

Due to the use of the smartphone, the student has confidence and recognizes that they have **full control of their data** (i.e., diploma) since it is they who present the evidence (i.e., personal data) directly to the evaluators and not exchanged mysteriously by evaluators and processors (e.g., ministries). This is an even bigger issue when the data is being exchanged cross-border.

Since the technology being used in the VC pattern (i.e., SSI, VC, DID, ZKP) enables also selective disclosure it gives the student even more options and confidence to share their, once-acquired personal data, not only to anyone they care to but also in the scope, they are willing to do so. Since students are always early adopters of technology, they are already naturally connected to smartphones, thus for them using our VC pattern's **mobile-first approach** is naturally more **user-friendly** and gives them satisfaction and confidence to use the digitalized processes.

3.2.1.4 Metrics for students

This subsection summarizes how the criteria relevant to students were met.

Table 15: Criterion C1

Criterion C1	The user acknowledges the procedure for applying for a service as efficient, effective and secure.
Metric C1.1	The satisfaction the user expresses on effectively completing the eProcedure.
Target	More than 50% of respondents are satisfied with the implemented procedure.

Criterion C1	The user acknowledges the procedure for applying for a service as efficient, effective and secure.
Results	As shown in Figure 17, 66% of the students were satisfied or very satisfied with the overall experience of the completed procedures in the three use cases. This is 10 percentage points higher than in the first iteration.
Metric C1.2	The satisfaction the user expresses on the eProcedure as being time-efficient.
Target	More than 50% of respondents are satisfied with the duration of the procedure.
Results	As shown in Figure 17, 81% of the students were satisfied or very satisfied with the duration of the procedures. This is 4 percentage points higher than in the first iteration.
Metric C1.3	The appreciation the user expresses on the eProcedure security and protection of his/her privacy.
Target	More than 50% of respondents are satisfied with the security and privacy protection.
Results	As shown in Figure 17, 80% of the students were satisfied or very satisfied with the security and privacy protection.
Metric C1.4	Control is given to students when managing their education credentials
Target	More than 50% of respondents are satisfied with the control they have when managing their education credentials.
Results	As shown in Figure 17, 81% of the students were satisfied or very satisfied with the control they had when managing their education credentials. There is no significant difference between the students using the USI (80,3%) or VC (81,6%) pattern.

3.2.2 Public administration users

In this subsection, the take up and value of the pilot services by the users from public administration and the feedback provided by them is analysed.

The value of the Studying Abroad pilot focuses on specific benefits (i.e. administrative burden reduction achieved by automated exchange of data across-borders following Once-Only principle) realised and verified with real students and members of students offices during cross-border piloting and comes from the fact that cross-border services are deployed with trusted evidence and verified cross-border interoperability. Staff of universities and Ministries of Education, as well as European students moving either physically or virtually to another university or using educational services such as applying for study grants, are the main actors involved in determining the benefits and value generated. The following results are based on interviews and filled questionnaires for DEs, DOs, and Member States. The questionnaires were described in more detail in D4.2 [2].

3.2.2.1 Data Evaluators

The assessment of the quality of student data when using DE4A OOP TS, compared to the traditional situation where DE4A OOP TS is not used, focused on the following aspects: availability of evidence in electronic and structured formats, and completeness, reliability, and meaningfulness of the available data.

Table 16 summarises the scores assigned by three Data Evaluators in UC#1 and UC#2 and one VC Verifier in the first iteration. It should be noted that this assessment is not based on the piloting with real users and real data in a production environment over an extended time. The pilot partners have not changed their assessment of these aspects in the second iteration. Numerical values were assigned to the appreciation rates as follows: very low (1), low (2), neutral (3), high (4), and very high (5).

Table 16: Quality of student data

Aspect	USI (n=3)	VC (n=1)
Availability in electronic format	4.67	4.00
Availability in structured format	3.67	3.00
Completeness of available data	4.00	4.00
Correctness of available data	5.00	5.00
Reliability of available data	5.00	5.00
Meaningfulness of available data	4.33	4.00

Respondents have also rated the effort required for processing students' data when using the DE4A patterns and solutions compared to the traditional situation (1 = considerably more effort, 5 = considerably less effort):

Table 17: Processing of student data

Aspect	USI (n=3)	VC (n=1)
Amount of work	4.67	4.00
Interpretation of data	3.33	4.00
Solving transcription and translation errors, missing data and exceptions	3.33	4.00

Some of the data issues mentioned by respondents are the lack of officially translated content. The benefits of the new procedure are higher compared to the traditional situation, but officially translated and normalised content would be crucial to increase the benefits of the system. It should be emphasised that the effort reduction in processing the evidence is not fully achieved if not all data required by the specific enrolment procedure is included in the evidence, since the administrative personnel must request the scanned copy of the certificates/diplomas containing the missing information to complete and validate the data in the old way. If all required data is provided, the validation procedure can save significant time, as, for example, currently the validation procedure at UJI can take days because of the volume of e-mails and phone calls exchanged with some applicants.

Data Evaluators also estimated the benefits of the integrated procedure compared to the costs and effort of customizing eProcedure portals and integrating them with the DE4A connector. As shown in Table 18, the benefits exceed the cost and effort for almost all aspects, (1 = benefits are considerably less than cost and effort, 5 = benefits considerably exceed cost and effort).

Table 18: Estimated benefits to DE / Verifier

Aspect	USI (n=3)	VC (n=1)
Lower manual effort of processing	4.33	4.00
Lower communication costs	3.67	4.00
Lower risk of errors	4.33	4.00
Shorter duration of application processing	4.33	5.00
More complete, valuable, consistent and correct data	4.00	4.00
Trustworthiness of the data	5.00	5.00

As noted above, the ability to obtain normalised data and official translations in the local language would increase benefits. English translation provides no benefit other than better comprehension for

staff, but official translation is still needed so that titles can be verified for the applied programme. In any case, regardless of being tabulated data, visual examination is required, as there is no way to automatically match a programme to a degree (in the sense that the knowledge acquired in that degree is valid for application to the programme).

Feedback from interviews

The INESC-ID team interviewed IST's director of academic services and the responsible for mobility. Both acknowledged the importance of the Studying Abroad mechanisms devised and piloted in DE4A. They said specifically that the problem of understanding if a diploma is authentic is a serious one and that the current process to do this validation is complex and time-consuming. The automatic validation provided by UC1 (evidence downloaded using the connector) and UC3 (verifiable credentials validated using data stored in EBSI) makes this process efficient and consumes no time at all, which is a great evolution concerning the current process. Notice that IST has around 12,000 students, so the scale of the problem fully justifies automatic validation mechanisms like these.

In the case of well-known universities, it can take a few minutes for a student office at IST in Portugal to validate paper-based evidence of foreign students. If that is not the case and there is suspicion about evidence, the process can take an hour or even more. On average, the time reduction with the DE4A procedure is around 20 minutes.

A workshop was also organized for representatives of university student offices involved in the enrolment of foreign students in Slovenian Higher Education Institutions and the procedure for recognition of diplomas both for Slovenian students wishing to study abroad and for foreign students wishing to have their diplomas recognized in Slovenia, to evaluate the benefits and obtain additional feedback. A total of 8 representatives from all four universities in Slovenia attended the workshop to share their experiences and benefits with DE4A cross-border procedures.

When foreign students enrol in higher education in Slovenia, student offices currently need to validate their diplomas. At this stage, they first search for the contact details of a relevant institution in the particular country and then prepare and submit a diploma validation request. This takes about 30 minutes per student. It is often difficult for them to find the information on where they need to send a request. In the case of the Netherlands, for example, no contact information is available, and the request must be entered into a special portal. Sometimes, it can take a week before they receive information about the authenticity and validity of the diploma. For some other EU countries, there have also been cases when they have not received any response at all. The DE4A procedure, therefore, saves at least 30 minutes of work per foreign student and ensures that the information about the validity of the diploma is always available from a trusted source.

Concerning the canonical evidence structure and domestic evidence, they would welcome the whole diploma supplement. They would also need information on whether the foreign higher education institution is an accredited institution.

Success story

Student office at UJI

When evaluating master's degree enrolment applications, UJI officials have to undergo a lengthy process of manual evidence validation, which includes the validation of the diploma that proves that the applicant has passed the undergraduate programme that is a requirement to access this master's degree programme.

An uploaded PDF copy of the diploma and grades certificate (with the average grade) is visually validated first, then compared to the data input by the user on the application (the input data is tabulated and used to rank the applications, so it must match the real diploma data), and finally, the university of origin has to be contacted (by phone or email) to validate that the diploma is not counterfeited. Also, the personal data of a student is open to input errors or impersonation attempts: a user creates a temporary account, with self-stated personal data, and an uploaded copy of the ID

document (passport, national ID card) which later requires an in-person validation by the officials, who will compare the physical document with the uploaded one.

DE4A allows time to be saved both to the student (less input, fewer errors, no need to scan and upload diploma and grades in PDF) and to the university officials (no email/phone checks), as it provides a high degree of trust on the received data, which is also tabulated and can be used for the ranking out of the box. Also, eIDAS provides a high trust in the personal data of the student, and it enables the creation of a full account, instead of a temporary one.

Metrics for data evaluators

Table 19: Criterion A1

Criterion A1	The DE recognizes the student data as of higher quality.
Metric A1.1	The appreciation the DE expresses on the quality of student data.
Target	More than 50% of respondents appreciate the quality (average of all perspectives) of student data when using the DE4A solution compared to the traditional situation where the DE4A solution is not used.
Results	All DE respondents appreciate the quality of the student data with an average value (of all perspectives) of 4.45 for the USI pattern and 4.17 for the VC pattern, as shown in Table 16, where 4.00 = 'high' and 5.00 = 'very high'.

Table 20: Criterion A2

Criterion A2	The DE recognizes the student data as easier to process.
Metric A2.1	The appreciation the DE expresses on the effort required for processing the student data.
Target	More than 50% of respondents appreciate the effort required for processing student data when using the DE4A solution compared to the traditional situation where the DE4A solution is not used.
Results	All DE respondents appreciate the effort required for processing the student data with an average value of 3.78 for the USI pattern and 4.00 for the VC pattern, as shown in Table 17, where 3.00 = 'same effort' and 4.00 = 'less effort'. The evidence validation procedure can save significant time, as currently it can take days in Spain because of the volume of e-mails and phone calls exchanged with some applicants. In Slovenia, the implemented procedure that replaces manual validation of foreign diplomas saves approximately 30 minutes per foreign student, and at IST in Portugal on average 20 minutes.

Table 21: Criterion D2

Criterion D2	The DE believes the cost and effort for integrating to the DE4A Connector will eventually be outweighed by the benefits.
Metric D2.1	The estimate of the DE on the benefits of the DE4A OOP TS in comparison with the effort and cost spent to customize the eProcedure portal and integrate with the DE4A Connector.
Target	More than 50% of respondents estimate that the benefits of using the DE4A OOP TS will exceed the costs and effort required to integrate the eProcedure portal with the DE4A Connector.

Criterion D2	The DE believes the cost and effort for integrating to the DE4A Connector will eventually be outweighed by the benefits.
Results	All DE respondents estimate that the benefits of using the DE4A OOP TS will exceed the costs and effort required to integrate the eProcedure portal with the DE4A Connector with an average value (over all perspectives) of 4.28, as shown in Table 18, where 4.00 = 'exceeding cost and effort' and 5.00 = 'considerably exceeding cost and effort'.
Metric D2.2	The effort (measured in person days) for customizing and integrating the eProcedure portal to the DE4A Connector.
Target	None
Results	As presented in Table 34, the average effort for customizing and integrating the eProcedure portal to the DE4A Connector was 34 person days. The effort excludes the preparation of different environments (test, preproduction, production), obtaining production certificates, and additional security assessments required by the IT departments of the pilot participants. Due to the small number of pilot participants and the differences in their experience with the DE4A components (DO was implemented by the connector developers), it is difficult to compare the DE and DO implementation efforts.

Table 22: Criterion E2

Criterion E2	The DE believes the cost and effort for integrating the SSI Authority agent will eventually be outweighed by the benefits.
Metric E2.1	The estimate of the DE on the benefits of the SSI Authority agent usage in comparison with the effort and cost spent to customize the eProcedure portal and integrate it with the SSI Authority agent.
Target	More than 50% of respondents estimate that the benefits of using the SSI Authority agent will exceed the costs and effort required to integrate the eProcedure portal with the SSI Authority agent.
Results	All DE respondents estimate that the benefits of using the SSI Authority Agent will exceed the costs and effort required to customize the eProcedure portal and integrate it with the SSI Authority agent with an average value (overall perspectives) 4.33, as shown in Table 18, where 4.00 = 'exceeding cost and effort' and 5.00 = 'considerably exceeding cost and effort'.
Metric E2.2	The effort (measured in person days) for integrating the SSI Authority agent in the eProcedure portal.
Target	None
Results	As presented in Table 35, the average effort for integrating the SSI Authority Agent in the eProcedure portal was 2.8 person days. The total effort including customization of the portal (excluding eIDAS integration) was 8 days. The effort excludes the preparation of different environments (test, preproduction, production).

3.2.2.2 Data Owners

Similar to Data Evaluators, the pilot partners providing evidence have also estimated the benefits of data provision compared to the costs and effort required to customize evidence portals and integrate them with the DE4A connector or the SSI Authority agent.

Table 23: Evidence request processing effort

Aspect	USI (n=4)
The effort required for processing requests for evidence	4.50

The benefits depend on the existing procedures for issuing diplomas at each participating institution. In Spain, for example, there are currently two ways to obtain diploma information. The first way is to apply at the Higher Education Institution (no single point of contact), either in paper format (great effort for the DO, which needs infrastructure to attend the student requests in person and print the certificates), or as a signed pdf (no effort for the DO, but not machine-readable for the DE, not all higher educational institutions can offer it this way, and in any case through different procedures). The newest process is through an electronic procedure on the Ministry of Education portal that allows checking the diploma personally or generating a verified link for a third party (not machine-readable, no effort for the DO, but some effort for the DE).

Table 24 gives an overview of how three data owners from UC#1 and UC#2 and two VC issuers from UC#3 rate various aspects. Again, it should be noted that this assessment is not based on the piloting with real users and real data in a production environment over a longer period.

Table 24: Estimated benefits to DO / Issuer

Aspect	USI (n=3)	VC (n=2)
Lower manual effort of processing	5.00	4.50
Lower communication costs	4.00	4.50
Lower risk of errors	5.00	4.50
Shorter duration of application processing	4.67	5.00

Aside from communication costs, it was estimated that all other benefits considerably exceed the cost and effort of customization and integration (the actual effort for the USI pattern is described below in Table 34 and the effort for the VC pattern in Table 35).

The effectiveness of record matching could not be fully evaluated as most students participating in piloting did not use real credentials and real data and the students with real evidence were selected for testing in advance. Nevertheless, record matching remains an important issue. In Spain, for example, a university receives for national services user's national ID in the service request and can search and return the data associated with the said national ID. No interaction with the user is required: either the data is found or not. Problems occur when degrees are awarded to foreign students. In this case, they are associated with their passport numbers possibly and usually with the foreigner's ID number that Spain requires any foreigner studying or working in Spain to get issued. If users use eIDs from their country of origin, the search will fail (given the sensitivity of the operation and the lack of a trusted date of birth, the matching by attributes is not allowed). The only way around this would be to authenticate the user at the university, which cannot be done due to the back-channel nature of the university service in relation to the central intermediary system for data provision.

Success stories

Student offices in Slovenia

The student office staff at Slovenian universities must respond to requests from foreign universities to validate the diplomas of Slovenian students continuing their studies abroad. For the third Bologna degree, this is done at the university level, for example at the University of Maribor. For other degrees, they forward applications to the relevant faculty, for example, the Faculty of Electrical Engineering and Computer Science. In these cases, it currently takes between 10 and 15 minutes to complete the form

in English and submit it to the foreign institution, which is not necessary anymore with the DE4A procedures.

Multiple evidence provision in Spain

The availability of multi-evidence support has it made possible for users to request data from different service providers in a single operation. Compared to single evidence exchange, implementing this feature raised the initial complexity, as in the case of Spain, where the Data Owner (SGAD) needed to establish communication with different administrations to obtain and merge the evidence retrieved: Higher Education Diploma is provided by UJI, Secondary education Diploma is provided by the Ministry of Education, and Large Family and Disability evidence is provided by different Autonomous regions. Since different sources implied different messaging structures, standardization became a must to mitigate complexity. Also having the playground environment ready allowed developers and technical teams to perform real cross-border testing to validate the implementation.

Metrics for data owners

Table 25: Criterion B1

Criterion B1	The DO recognizes the requests for evidence as easier to process.
Metric B1.1	The appreciation the DO expresses on the effort required for processing requests for evidence.
Target	More than 50% of respondents appreciate the effort required for processing student data when using the DE4A solution compared to the traditional situation where the DE4A solution is not used.
Results	Three quarters of the respondents appreciate the effort required for processing the evidence requests and one quarter finds the effort the same as before. As shown in Table 23, the average value was 4.50, where 4.00 = 'less effort' and 5.00 = 'considerably less effort'.

Table 26: Criterion D1

Criterion D1	The DO believes the cost and effort for customizing the Evidence portal and data service and integrating to the DE4A Connector will eventually be outweighed by the benefits.
Metric D1.1	The estimate of the DO on the benefits of the DE4A OOP TS usage in comparison with the effort and cost spent to customize the Evidence portal and integrate with the DE4A Connector.
Target	More than 50% of respondents estimate that the benefits of using the DE4A OOP TS will exceed the costs and effort required to integrate the Evidence portal with the DE4A Connector.
Results	All DO respondents estimate that the benefits of using the DE4A OOP TS will exceed the costs and effort required to integrate the Evidence portal with the DE4A Connector with an average value (over all perspectives) of 4.67, as shown in Table 24, where 4.00 = 'exceeding cost and effort' and 5.00 = 'considerably exceeding cost and effort'.
Metric D1.2	The effort (measured in person days) for customizing and integrating the Evidence portal to the DE4A Connector.
Target	None
Results	As presented in Table 34, the average effort for customizing and integrating the Evidence portal to the DE4A Connector is nearly 52 person days.

Table 27: Criterion E1

Criterion E1	The DO believes the cost and effort for integrating the SSI Authority agent will eventually be outweighed by the benefits.
Metric E1.1	The estimate of the DO on the benefits of the SSI Authority agent usage in comparison with the effort and cost spent to customize the Evidence portal and integrate it with the SSI Authority agent.
Target	More than 50% of respondents estimate that the benefits of using the SSI Authority agent will exceed the costs and effort required to integrate the Evidence portal and data service with the SSI Authority agent.
Results	All DO respondents estimate that the benefits of using the SSI Authority Agent will exceed the costs and effort required to customize the Evidence portal and integrate it with the SSI Authority agent with an average value (over all perspectives) of 4.63, as shown in Table 24, where 4.00 = 'exceeding cost and effort' and 5.00 = 'considerably exceeding cost and effort'.
Metric E1.2	The effort (measured in person days) for integrating of the SSI Authority agent in the Evidence portal.
Target	None
Results	As presented in Table 35 the average effort for integrating the SSI Authority Agent in the portal is 2.8 person days. The total effort including customization of the portal (excluding eIDAS integration) is 10 days.

3.2.2.3 Member states

The participating member states were asked to estimate the benefits compared to the costs, effort, and time required to setting up and deploying the AS4 gateway, the SMP, and the DE4A Connector focusing on implementation, maintenance, training, and the duration of application processing (1 = benefits are considerably less than cost, effort and time, …, 5 = benefits considerably exceed cost, effort, and time). As only two MSs provided their answers, particular national issues (e.g. extensive security testing in Portugal) influenced the final results.

Table 28: Estimated benefits to MS

Aspect	Score (n=2)
Effort and cost of implementation	3.00
Effort and cost of maintenance	4.50
Effort and cost of training	4.00
Shorter duration of application processing	5.00

Metrics for member states

Table 29: Criterion D3

Criterion D3	The participating Member State believes the cost and effort for setting up and deploying the AS4 gateway, the SMP and the DE4A Connector will eventually be outweighed by the benefits.
Metric D3.1	The appreciation the Member State expresses on the effort, cost and time needed for deploying the AS4 gateway (if separate from the DE4A Connector), the SMP DE4A Connector.

Criterion D3	The participating Member State believes the cost and effort for setting up and deploying the AS4 gateway, the SMP and the DE4A Connector will eventually be outweighed by the benefits.
Target	More than 50% of respondents estimate the cost and effort for setting up and deploying the AS4 gateway, the SMP and the DE4A Connector will eventually be outweighed by the benefits.
Results	Only two of three piloting MS provided this data. One MS estimates that the benefits will exceed the effort and cost of implementation, maintenance and training, and the other does not, as shown in Table 28.
Metric D3.2	The effort (measured in person days) for deploying the DE4A OOP TS.
Target	None
Results	Only two MS provided this data. It takes on average almost 7 days to set up an SMP and nearly 6 days to deploy a DE4A connector with an integrated phase4 AS4 gateway. Integration of an external AS4 gateway (Domibus in particular) takes between 15 and 20 days due to complex, static configuration highly dependent on other participants involved, as shown in Table 34.

3.2.2.4 Project and external communities

The pilot has contributed to the expected DE4A benefits as a project and in relation to the external community of SDG stakeholders in several ways. It has validated the project start architecture, the User-supported Intermediation and the Verifiable Credentials patterns, as well as the canonical model for higher education diplomas. The pilot has also validated the common components such as DE4A Connector and SSI Authority Agent and the underlying evidence exchange infrastructure. Finally, the pilot partners have provided feedback to the SDG semantic working group on the higher education evidence scheme.

The usefulness of DE4A patterns and components

Pilot partners involved in customization, implementation, deployment, or testing of DE, DO, and DE4A Connector provided feedback on the common components and specifications, see more information about such common components here: https://wiki.de4a.eu/index.php/DE4A_common_specifications_and_components_it2.

First, they rated different aspects of the common components, such as perceived quality of specification and software, ease of integration, the potential to include the components in the sustainability plan, and their adequacy for pilot purposes. Not all aspects have been rated by every partner. For example, the SSI authority agent and the SSI user agent were relevant only to the partners involved in UC#3. The answers were assigned numerical values as follows: very low (1), low (2), neutral (3), high (4), and very high (5). Average values for each component and aspect are available in Table 30.

Table 30: Usefulness of components

Components	Perceived quality of specs/ software	Ease of integration	Potential to include in a sustainability plan	Adequacy for pilot purpose	Overall assessment
Solution architecture (n=6)	3.67	3.20	3.67	4.60	3.78
Information exchange model (n=5)	3.80	3.75	3.80	4.50	3.96

Canonical data model (n=5)	3.80	4.50	3.80	4.50	4.15
DE4A connector (n=5)	3.80	4.40	4.00	4.75	4.24
Mock DE (n=5)	4.40	4.20	4.00	4.20	4.20
Mock DO (n=5)	4.40	4.20	4.00	4.20	4.20
Central SMP (n=4)	4.50	4.00	4.00	4.67	4.29
Kafka server (n=5)	4.60	4.00	4.25	4.75	4.40
SSI authority agent (n=3)	3.33	3.33	4.00	4.00	3.67
SSI user agent (n=3)	4.00	4.33	4.00	4.50	4.21

The results show that the usefulness of all components was generally perceived as high (with scores around 4.00), with the highest scores given to the usefulness of the Kafka server in the playground (4.40). Among the aspects assessed, suitability for the pilot purposes was rated highest by the pilot partners, and the potential to include all components in the sustainability plan was rated lowest, but still positive. Subcontractors who were not directly involved in the day-to-day project activities perceived integration as more difficult due to the lack of appropriate documentation and background knowledge.

The pilot partners would appreciate reference implementations of specific functionalities, such as schema validation, in different languages (not just in Java) to facilitate faster integration of the solutions, but this required additional resources which were not available in the project.

Preproduction eIDAS environments in all three MS occasionally faced issues that made testing and integration more difficult, e.g. maintenance, delays in changing expired certificates, changes in configuration, or unstable OCSP service. The eIDAS environments are maintained by organizations that are external to the project.

Technical support and testing

Another topic of assessment was quality of support, technical documentation, and testing methodology. The main support and communication channel for developers was Slack, complemented by the project mailing lists, Connectathons, and the discussions at pilot meetings. Pilot partners rated the adequacy of various aspects, and their responses were assigned numerical values as follows: absolutely inadequate (1), inadequate (2), sufficient (3), adequate (4), and perfectly adequate (5). As can be seen from Table 31, respondents were very satisfied with the support and communication channel (Slack) provided during integration and testing. For the final iteration, the technical documentation has been improved and published in the wiki.

Table 31: Support and testing

Criteria	Score (n=6)
Quality of support and communication channel (Slack) provided by common components WP during the integration and testing	4.50
Quality of technical documentation	3.17
Contribution of testing methodology and Connectathons for testing with other MS to the successful launch of the pilots	3.67

3.2.3 Learning towards Adoption

This section describes the lessons learnt from piloting the Studying Abroad use cases in both iterations. The knowledge was built in different phases, from customization and integration to testing, and was

found useful for different purposes, namely to provide it to other work packages, help the adoption of services, and promote sustainability.

3.2.3.1 Approach to knowledge-building

Knowledge in DE4A was built up in several phases with different actors gaining experience and contributing to the various topics:

- Student feedback form (online questionnaire for students published on the pilot microsite);
- Interviews with university student offices in Portugal, Slovenia, and Spain.
- Internal discussion between service providers and questionnaires for DEs, DOs, and MSs;
- Further discussion between service providers and other governmental institutions;
- Actors with a converging line of work, like other members of the EBSI Early Adopters programme.

Besides generating knowledge, the other aim for this pilot was to share and preserve it for the benefit of all stakeholders, especially other work packages and future adopters. The followed methodology was to keep a direct and ready interaction via e-mail and teleconference with interested parties, seeking a mutual benefit and generating discussion. Wiki was also used to share information on the pilot endpoints, use cases, and cross-border interoperability status. The most relevant of these lessons are documented and reported in this document, as a source for future adopters.

3.2.3.2 Lessons learnt from design, customization, integration, and testing

Pilot partners designing, customizing, integrating, and testing their solutions learnt various lessons that are gathered in this section. For each lesson learnt, a suggestion for adoption is presented. Table 32 summarizes lessons for the analysis and design phase, while the lessons relevant to customization, integration, and testing are presented in Table 33. For every lesson learnt, suggestion for adoption is provided in the form of advice to, for example, the European Commission and/or EU Member States.

Table 32: Analysis and design

ID	Topic	Suggestion for adoption	Lessons learnt
1.	Design process	SA advises the Member States to invest time to bring together the eIDAS and OOTS knowledge.	The design of national integration required in-depth knowledge of both eIDAS and OOTS. This knowledge (especially the combination of both) is not broadly available in MS as integration with eIDAS and eDelivery infrastructures normally involves different experts. The knowledge of both domains should be brought together.
2.	Scope	SA advises the Member States to pay attention to the difficulties that may arise for some of the SDG procedures from the higher education domain due to national barriers.	Some of the SDG procedures are difficult to be implemented online due to various barriers in MS, such as regional jurisdiction over enrolment to the 1st Bologna degree in Spain, the lack of evidence required for the procedures (e.g. for grant applications, or disparity over the evaluation criteria (e.g. different interpretation of the data).
3.	Evidence	SA advises the Member States to consider burdens imposed by the	It was difficult to find a common denominator of higher education evidence from the three MS for

ID	Topic	Suggestion for adoption	Lessons learnt
		variety of higher education evidence in MS.	applications to higher education and applications for study grants (some data required by one MS might not be obtainable from another MS). This will become even more difficult when doing the same among all MS. Many MS also have difficulties providing the evidence required for certain procedures, e.g. non-academic evidence for the applications for study grants that can contain sensitive personal data.
4.	Evidence	SA advises the European Commission and Member States to harmonize evidence data models in the higher education domain defined by SDG WG and Europass. Furthermore, workshops should aim to include analysis by the largest possible amount of MS to avoid issues where decisions on required evidence types and mandatory/optional attributes for procedures may conflict with data availability.	The pilot suggested to the DE4A Semantic Interoperability Solutions work package WP3 the Europass data model as the basis for the higher education diploma scheme to be able to use the same schema for both USI and VC pattern (and thus between SDG OOTS and revised eIDAS regulation).
5.	Multiple evidence cases	SA advises the Member States to set up national OO gateways (e.g. national data exchange infrastructure acting as gateway/proxy towards cross-border peers and hiding internal details/complexity).	Pieces of evidence of multiple types are typically required by calls for study grants. This evidence can be provided by different data providers. National OOTS (e.g. acting as DT for multiple DOs) and centralised preview components that enable a single request for multiple evidence types can reduce the complexity of the procedure.
6.	Multiple country scenario	SA advises Member States to focus first on the 2-Member States scenario and then make an early start with the analysis of the SDG implementation where data exchange can involve more than two Member States.	Applications to higher education or for study grants may involve multiple countries if students from MS A have completed part of their education in MS B and wish to access a service in MS C. This complex scenario has not been piloted in the second iteration.
7.	eIDAS non-notified eID	SA advises the European Commission and the MS without notified eIDs to agree on a temporary solution for the use of non-notified eIDs in the SDG procedures (as risk exists of having MS without notified eIDs	Slovenia does not operate a notified eID at the time of piloting. On a bilateral basis, non-notified eIDs were accepted for piloting purposes, although pilot partners expressed their doubts regarding about acceptability of non-notified eIDs for large-scale SDG.

ID	Topic	Suggestion for adoption	Lessons learnt
		by the time the SDG OOTS should be integrated with MS infrastructures and operational). Plans for notifications from these MS should be carefully assessed to determine negative impacts on citizens. Deployment timelines of eIDAS wallets also have to be considered.	Notification of eIDs is an important prerequisite for SDG implementation.

Table 33: Customization, integration, and testing

ID	Topic	Suggestion for adoption	Lessons learnt
1.	Planning and organising tasks	SA advises allocating a multi-month phase for establishing alignment, priorities, financial means, etc. for all organizations involved. Furthermore, it is necessary to have a coordinating team (equipped with sufficient knowledge about the solution) in each Member State to make sure that legal, semantical, technical, and managerial issues are being resolved on time.	The components deployed and used in the pilot were distributed over several authorities in a Member State, requiring commitment from all authorities.
2.	Hand-over procedure	SA advises the European Commission to put additional efforts into explaining the workings of the SDG OOTS components to the public authorities involved.	The design documents and specifications were sometimes interpreted in different ways by the different pilot partners.
3.	Integration of DP and DC	SA advises Member States to consider the concept of national central services where different DEs and DOs can connect to.	The concept of a Connector with an integrated AS4 gateway allowed for easier integration of DEs and DOs in the USI pattern. Decoupling the exchange and business layers allows for abstraction and adds flexibility to the exchange model.
4.	Integration of DP and DC	SA advises the European Commission to prepare reference implementations of common components that the Member States can use for the integration.	The DE4A Connector reference implementation helped MS to integrate their data evaluators and data owners and enable connectivity between the states more easily.

ID	Topic	Suggestion for adoption	Lessons learnt
5.	Integration of national components	SA advises Member States to foresee as much as possible the constraints of internal decision-making procedures inside MS.	Deployment delays were undergone in some Member States due to the complexity of internal IT department procedures, additional security audits, and subsequent testing of the overall architecture and individual components.
6.	Integration of national components	SA advises Member States not to underestimate the effort to integrate national systems with the central components and infrastructure and to anticipate different levels/paces of progress in the MS developments/ deployments.	The system is very complex and required significant effort to learn the technical specifications. Integration with the project infrastructure and other national systems was more complicated than originally anticipated by the partners, also due to the involvement of multiple organisations.
7.	Integration of national components	SA advises the European Commission and Member States to make available Playground for integration testing.	The DE4A playground with mock DE, mock DO test connectors, and shared test SMP proved successful for validating national connectors and SMP installations and easier DE and DO integration.
8.	Interoperability testing	SA advises testing thoroughly connectivity/interoperability between Member States before cross-border Connectathon sessions for endpoints.	Connectivity and cross-border interoperability between endpoints were successfully tested at DE4A Connectathons where developers from pilot partners had previously fixed other interoperability issues. Sharing of information about up-to-date key technical configurations (identifiers, redirection URLs…) was of paramount importance as end-to-end connectivity depends completely on having these configurations correctly implemented.
9.	Interoperability testing	SA advises the European Commission and Member States to arrange a coordinated exchange of test credentials.	Cross-border interoperability testing requires easy access to the test credentials of the test users with various test evidence.
10.	Interoperability testing	SA advises the Member States to increase the usage rate of eIDAS authentication.	Students typically don't have their eIDAS-based authentication means, e.g. citizen cards, activated for eIDAS authentication.
11.	Cooperation	SA advises the European Commission and Member States to establish a channel for collaboration of the MS technical experts.	Slack appeared to be a good tool for collaboration between developers from different MS / WPs.

Pilot partners also estimated the required effort for various steps, such as integrating the DE4A Connector or implementing the Preview functionality. Effort for both patterns is summarized in the following tables based on answers from three DEs and two DOs for the USI pattern, two VC issuers, one VC verifier, and two MS. This effort excludes preparation of different environments (test, preproduction, production), obtaining production certificates, and additional security assessments required by IT departments of the pilot participants.

Table 34: Estimation of effort for the USI pattern

Phase	Mean effort (in person days)
Setting up and deployment of external AS4 gateway (n=1)	17.50
Setting up and deployment of DE4A Connector (n=2)	6.75
Setting up and deployment of SMP (n=2)	5.75
Integration of the portal with an eIDAS node (n=5)	8.40
Integration with DE4A Connector (n=5)	12.50
Implementation of Explicit Request (n=3)	7.33
Implementation of Preview (n=2)	15.75
Transformation to canonical format and provision of the requested evidence (n=2)	6.25
Transformation from canonical format and use of the received evidence (n=3)	6.33
UI internationalization (n=5)	3.10
Overall effort for DE (n=3)	34.00
Overall effort for DO (n=2)	51.50

DE4A Connector already integrates the Phase4 AS4 gateway, which makes setting up the AS4 gateway very easy. More effort (17.5 person days) was needed by Spain in the case of the test deployment of Domibus which is more complex and static configuration is highly dependent on other participants involved.

Due to the small number of respondents, the different skills of the partners involved, and the differences in the partners' environments, it is difficult to compare the overall effort for DE and DO implementation and integration.

Table 35: Estimation of effort for the VC pattern

Phase	Mean effort (in person days)
Integration of the SSI Authority agent with the portal (n=3)	2.80
Customization of the portal (n=3)	2.80
Transformation to canonical format and provision of the requested evidence (n=2)	2.80
Data transformation from canonical format and use of evidence (n=1)	1.00
UI internationalization (n=3)	1.50
Overall effort for Issuer (without eIDAS integration) (n=2)	10.00
Overall effort for Verifier (without eIDAS integration) (n=1)	8.00

3.2.3.3 Technical, semantic, and organisational/legal knowledge provided to other WPs

The Studying Abroad pilot has been in constant interaction with other work packages collaborating and providing mutual benefit through discussion and feedback. Several lessons learnt have been beneficial to other WPs.

Table 36: Lessons learnt for other WPs

ID	Topic	Suggestions	Lessons learnt
1.	Evidence	Evidence should be complete with normalized values and officially translated content. Different versions of canonical evidence with only mandatory elements could be defined instead of one version that also includes optional elements.	The effort reduction in processing the evidence cannot be fully achieved if not all data required by the specific procedure is included in the evidence. The average degree was added to the diploma canonical evidence in the final iteration for ranking enrolled students in Spain.
2.	Clarity and simplicity of the procedures	Special emphasis should be put on the clarity and simplicity of online procedures in the higher education domain.	The procedures can become very complex and require multiple interactions with various components, such as eIDAS-based authentication, OOTS, portals, or devices. VC pattern was simplified by WP5 in the final iteration to reduce the number of interactions with a portal and mobile device.
3.	Documentation	Proper and clear documentation for developers facilitates the easier establishment of the OOTS and running with the least possible effort.	The design documents and specifications sometimes lacked necessary details or were changed during the first iteration. Clear and detailed documentation was especially important for organisations that were not pilot partners involved in the day-to-day project activities and lacked the background, such as the subcontractors. The Wiki has made life easier for the developers in the second iteration, as anyone could

ID	Topic	Suggestions	Lessons learnt
			access the required information[12].
4.	Communication	Use visual tools to show the benefits of OOP to users, e.g. presentations and videos. Prepare the creation of an animation by setting up a good storyline and slides that illustrate the flow of the animation.	Implementation of OOP might be interpreted as abstract by users that might benefit from it. From the user's perspective, there's not too much to see in the OOP process. Hence, additional efforts are needed to explain understandably the huge difference that OOP makes.

3.2.3.4 Other lessons from interaction with other initiatives

To pilot the UC#3 (Diploma recognition), the proposed VC pattern requires the student's direct interaction using an SSI Mobile User Agent with the SSI Authority Agent (deployed on the Issuer/Verifier side) and indirect interaction with the EBSI (European Blockchain Service Infrastructure) using the APIs defined at the level of ESSIF (European Self-Sovereign Identity Framework). The interaction is of high importance, as the Issuers use EBSI-compliant public DIDs to sign the issued VCs (i.e., Verifiable Attestations – Diplomas), whereas the Verifiers validate the submitted VPs from students by retrieving information about the diploma issuer from the EBSI DID Registry and Trusted Issuers Registry (TIR). Within the verification procedure both parties have to communicate with the EBSI DID Registry and TIR to ensure the validity and transparency of the entire process flow.

During the pilot implementation, the EBSI API endpoints were frequently changing due to new releases, which presented a bottleneck to the pilot implementation efforts, since new changes required changes in the SSI agent implementation (both Authority Agent as well as SSI mobile agent). By the end of the first iteration, the EBSI APIs were more stable and mature and the interaction with EBSI was stable enough to proceed with piloting the VC pattern in pre-production. During the second iteration, the EBSI APIs used by the DE4A technical components (SSI agents in UC#3) were migrated from the "pre-production" to the "pilot" environment. This was due to the introduction of the "production" environment, which also brought upon the differentiation between EBSI environments, i.e., production, pre-production, and pilot. For each of these, the users of their services had to sign appropriate documents related to GDPR, etc. This triggered the need to update the DE4A SSI agents accordingly (i.e., connection to the pilot environment), which was sometimes affected by the occasional unavailability and frequent minor changes of EBSI APIs in the new environment.

Moreover, some features (e.g., registering the Issuer into the EBSI TIR) are still not supported by the EBSI APIs and cannot be done fully automatically at this point, so the Issuer organizations need to put additional manual efforts into the direct communication with EBSI Support team.

The diplomas issued in the VC form follow the Europass data model, which has also been implemented in the ESSIF's diploma schema. Nevertheless, the standardization of the ESSIF diploma schema is still an ongoing effort (including also the availability of relevant APIs), so the current VCs issued by the Issuers are using the W3C data model schema but introduce the diploma-related Europass data model's attributes as well (e.g. achievements).

[12] See a good example of Getting Started guide for Member States here: https://wiki.de4a.eu/index.php/Getting_started_guide

Furthermore, the VC pattern focuses on the immediate relation/connection between the SSI and the eID/eIDAS technical backgrounds, thus we excluded the idea of students having ESSIF Verifiable IDs (based on EBSI DIDs) and introduced the eIDAS Minimum Data Set as additional parameters in the VC. This additionally deviated from the EBSI/ESSIF VC schema. However, during the time of the 2nd piloting phase, EBSI also changed some of its concepts related to DIDs, whereby they differentiated natural and legal-based DIDs. The latter had to be anchored on the EBSI DID Registry and are technically based on the previous schema version, while the DID schema for natural persons was updated and the idea of Verifiable IDs was also struck away from their vision. This did not affect SA piloting and systems since DE4A never planned to use public DIDs for students, hence chose an alternate approach with the inclusion of eIDAS MDS in the subject parameter of VCs, which was then used for matchmaking purposes during the verification phase. Furthermore, the VC schema validation process was envisioned to be supported by the EBSI Trusted Schema Registry, which however was still not accessible before and during SA Pilot's second piloting phase. Hence, our VC schema verification process is performed locally by using Hyperledger Aries. However, there were ongoing discussions with the EBSI/ESSIF schema development team to register the DE4A VC schema, but the process requires approval from the EBSI team and, hence, it was delayed. Furthermore, EBSI also shifted its focus toward JWT-based presentations instead of JSON-LD based, which however was not outlined before the second piloting phase started. Additional details regarding DE4A's Self-Sovereign Identity Framework and integration with EBSI Early Adopters Programme can be found in D5.8 [7].

3.2.3.5 Project-oriented metrics

Table 37: Criterion F1

Criterion F1	Real education services are developed, successfully connected, and piloted as fully online cross-border procedures to the DE4A interoperability infrastructure by the respective pilot partners
Metric F1.1	The functional tests are successful, the cross-border services are in use, and the evidence is provided in an electronic structured format from trustworthy sources.
Target	All tests are performed successfully
Results	All planned combinations were launched and piloted.

Table 38: Criterion F2

Criterion F2	The Higher Education Evidence Models have proven adequate for the cross-border exchange of information on students for the SA eProcedures
Metric F2.1	The appreciation of the DE on the extent to which the Higher Education Evidence Model fits their needs.
Target	None (research topic)
Results	As shown in Table 30, the overall assessment of the Higher education diploma evidence model was 4.15, where 4 = 'high' and 5 = 'very high'. The average grade element was added to the data model for the second pilot iteration. The other three evidence models (completion of secondary education, large family, disability) were not evaluated by the administration staff as they were only used in test services.

Table 39: Criterion F3

Criterion F3	The explicit request and preview requirements as specified in the SDGR have proven suitable for higher education eProcedures
Metric F3.1	The users' appreciation on the clarity of the Explicit Request and Preview steps.
Target	None (research topic)
Results	The majority of the users who provided feedback on this topic appreciated the clarity of the Explicit Request and Preview steps, i.e. 41 out of 47 (87 %) for Explicit request and 44 out of 47 (94%) for Preview. 47 students did not answer this question.

Table 40: Criterion F4

Criterion F4	The mechanisms for record matching at the DO have proven adequate for the SA eProcedures
Metric F4.1	The appreciation of the DO on the effectiveness and difficulties of record matching on students.
Target	None
Results	The effectiveness of record matching could not be fully evaluated as most of the students (83%) participating in piloting in the final iteration did not use real credentials. Spanish students with test credentials used real, but randomly selected and anonymized data, while few Slovenian students with real credentials were preselected. In Portugal, six tests were performed with real eIDs.

3.3 Technical common criteria

From a technical perspective, the services piloted in DE4A must adhere to several common criteria. The following Table 41 describes how each of the DE4A technical common criteria was met by the pilot in the final iteration.

Table 41: Reflection per technical common criteria

ID	Criterion	
1.	Openness	The services are based on open source software technologies to avoid a lock-in effect and allow fast adaptation to business needs. The common components developed within DE4A are available on GitHub[13] and the entire documentation is publicly accessible on the DE4A wiki[14].
2.	Transparency	All pilot-related procedures are traceable and transparent for all the stakeholders involved and interoperability is supported by the availability of interfaces to systems and data. The procedures and their status are described in the DE4A wiki and the DE4A SA pilot microsite. The students were informed on the piloting conditions and what it meant to participate in the pilot by their pilot session supervisors, through the microsite, and on the procedure portals. Internally, an MoU also provides for MS authorities transparent information on requirements, assurances, and limitations in relation to piloting.
3.	Reusability	The procedures use existing building blocks (e.g. CEF), standards, and infrastructure (e.g. eIDAS and authentic evidence sources), as well as DE4A

[13] https://github.com/de4a-eu
[14] https://wiki.de4a.eu/index.php/DE4A_Service_Interoperability_Solutions_Toolbox

ID	Criterion	
		building blocks, such as DE4A Connector or Authority agent. EBSI/ESSIF building blocks were used at their current stage of development by the Authority Agent to implement the functionalities of the DE4A SSI supporting framework (e.g. registering the identifiers of Issuers/Verifiers in the EBSI registries, i.e. ledger).
4.	Technological neutrality and data portability	The majority of the service infrastructure does not depend on vendor-specific technologies (e.g. specific AS4 gateway implementation) or specific technical implementations but rather re-uses open source software, which further enables the ease of data sharing/free movement of data. The only exception is a DE4A digital wallet that has only been developed for Android-based mobile phones given resource limitations, but which can be used with different Android versions.
5.	User-centricity	In all three use cases, users are given control when managing their educational credentials, i.e. higher education diplomas, and this control has been highly appreciated by the pilot participants, as shown in Figure 17. UC#1 and UC#2 implemented and piloted user-centric features of the USI pattern, such as reauthentication and Preview at the data provider side. User-centric SSI approach was piloted in UC#3.
6.	Inclusion and accessibility	The services offer an acceptable degree of usability that depends on the standards applied by the pilot partners. Nevertheless, the clarity and simplicity of the procedures could be improved as mentioned by some of the pilot participants. This has already been considered for the second iteration by simplifying the procedure in UC#3. Most of the services are available in both English and the national language.
7.	Security and privacy	Authenticity, integrity, and confidentiality of data exchanged through the common infrastructure are guaranteed in UC#1 and UC#2 by the eDelivery systems and the TLS connections between DEs and DOs and connectors. Verifiable credentials in UC#3 are digitally signed to ensure authenticity and integrity. Secure communication in UC#3 is guaranteed with the DIDComm protocol and reading of a QR code to link mobile and PC sessions. For privacy protection, an MoU was signed by all MS, and Data Protection Officer (DPO) was designated before and during the project. Users preview their evidence before transfer across borders and decide by themselves whether to give consent or not for the transfer. No incidents occurred during the pilot run. Security and privacy have been highly appreciated by the pilot participants, as shown in Figure 17.
8.	Administrative simplification	As described in previous sections, DEs and DOs appreciate the reduction in effort required for processing of student data. Currently, the non-DE4A evidence validation procedure at DEs can take from 20 minutes to days because of the volume of e-mails and phone calls exchanged with some applicants or no responses to evidence validation requests.
9.	Effectiveness and efficiency	The piloted procedures produce the intended result and enable the students, DEs, and DOs to accomplish their goals.

4 Pilot Procedures

4.1 Cross-border pilot testing approach

Connectivity of the Member states and cross-border interoperability between data consumers and data providers were tested at DE4A Connectathons where developers from all pilot partners participated. In total, 13 connectathons were organized between September 2022 and February 2023.

First, the connectivity of the DE4A connectors was tested with the help of mock DEs and mock DOs from the playground. Then, the integration of real DEs and DOs was validated with mock DOs and mock DEs respectively. In the final stage, cross-border interoperability of real DEs and real DOs was tested[15]. Both happy and unhappy flows were investigated:

- DE4A Connectivity
  - Happy flow, unhappy flow (no evidence, rejected preview)
    - Mock DE – DR (MS A) – DT (MS B) – Mock DO
    - Mock DE – DR (MS B) – DT (MS A) – Mock DO
- Integration of endpoints
  - Happy flow, unhappy flow (no evidence, rejected preview)
    - DE (MS A) – DR (MS A) – DT (MS B) – Mock DO
    - Mock DE – DR (MS B) – DT (MS A) – DO (MS A)
- Cross-border interoperability of endpoints
  - Happy flow, unhappy flow (no evidence, rejected preview)
    - DE (MS A) – DR (MS A) – DT (MS B) – DO (MS B)
- Verifiable credentials
  - Happy flow, unhappy flow
    - Mobile user agent – Issuer (MS A)
    - Mobile user agent with a VC from MS A – Verifier (MS B)

Guidelines and checklists for participation in Connectathons have been prepared for the second iteration that asked for more detailed preparation and configuration testing before the Connectathons (see https://wiki.de4a.eu/index.php/DE4A_Playground_it2 and https://wiki.de4a.eu/index.php/DE4A_Checklist_for_Connectathon).

4.2 End users' engagement progress and dissemination/impact activities

The core of the user-engagement strategy was to ensure there were enough users for whom the cross-border services were aimed to achieve a successful set of piloting activities. The users include both students and university administration staff. The following table shows the students who were eligible for the final iteration, as their data was available in the integrated data and could be exchanged through the DE4A OOP Technical System or with Verifiable Credentials/Verifiable presentations.

Table 42: Eligible students for piloting in the final iteration

MS	Data owner
ES	Students of University Jaume I with the 1st level Bologna degree diploma
SI	All Slovenian students with the 1st level Bologna degree diploma

[15] Additional details regarding how testing approach was planned can be found in Section 4.3 of D4.2 [2].

PT	Students of Instituto Superior Técnico (University of Lisbon) with the 1st level Bologna degree diploma

A goal for the final iteration was to double the number of students from the first iteration (from 50 to 100) and also to consider other types of end users (administration staff at universities). In comparison to the first phase, students from other departments of the participating universities who were not involved in any way with the project were invited to participate in piloting. A longer period of piloting also contributed to the higher number of students. The number of students using the services and providing feedback has been increased to 104, but it should be noted again that testing was by invitation only, as the testing period generally did not overlap with open official calls for enrolment and there were no legal consequences of submitted applications.

Students have been asked to provide formal feedback through an online evaluation tool to help us understand their views on the pilot. Before they participated in the pilot, the students were provided with participation guidelines, including service walkthroughs and recordings of the procedures. The participation guidelines have been published on the pilot microsite (https://www.de4a.eu/studyingabroadpilot).

University administration staff in the three participating Member States was interviewed to collect their experience with the implemented procedures from the university's point of view. The main focus of the interviews was to obtain feedback on the benefits that DE4A procedures bring to universities, especially the time savings.

In the rest of this subsection, more details about the user engagement activities of the participating Member States are provided. The pilot was also disseminated at various events, for example

- EUNIS annual conference, Göttingen, June 1-3, 2022,
- EEMA annual conference, London, June 8-9, 2022.
- DE4A Final Event (online), April 2023.

4.2.1 Portugal

INESC-ID devised a strategy to engage students from IST for the pilot, as explained in D4.2 [2]. However, real students apply to programmes at specific times of the year, that do not match the time the consortium was completing the two iterations of the pilot. Specifically, the second pilot iteration happened in late 2022 and early 2023 when there were no student applications open in the universities involved in the pilot. Therefore, INESC-ID engaged in the pilot real students from IST that were doing their MSc or PhD at the lab or with whom they had direct contact, but that did not specifically aim to apply to a program in a university in Spain or Slovenia; they emulated that application with the portals that would normally be used to do so.

The INESC-ID team also interviewed IST's director of academic services and the responsible for mobility. Both acknowledged the importance of the study abroad mechanisms devised and piloted in DE4A. They said specifically that the problem of understanding if a diploma is authentic is a serious one and that the current process to do this validation is complex and time-consuming. The automatic validation provided by UC1 (evidence downloaded using the connector) and UC3 (verifiable credentials validated using data stored in EBSI) make this process efficient and consumes no time at all, which is a great evolution in relation to the current process. Notice that IST has around 12,000 students, so the scale of the problem fully justifies automatic validation mechanisms like these.

4.2.2 Slovenia

The Slovenian students who were participating in the pilot testing had been selected from the University of Maribor, Faculty of Electrical Engineering and Computer Science (FERI). UM directly engaged master's and PhD students with advanced IT skills and currently studying at FERI. UM checked that the information about their previous study degrees in Slovenia can be provided by the relevant

ministry. The selected students did not plan to apply for any international programmes at other universities, but they were willing to test the solutions developed within the pilot and consent that their education data was used for piloting purposes. As the DE4A Data owner at the Ministry of Education, Science and Sport of the Republic of Slovenia was established in the preproduction environment, all selected students had to sign a separate GDPR form that allowed the ministry to copy their real diplomas from the production to the preproduction system for the piloting purposes.

Ministry of Education, Science and Sport of the Republic of Slovenia and Jožef Stefan Institute organized a workshop on January 18, 2023, for university student office representatives who are involved in the enrolment of foreign students to Slovenian higher education institutions and the diploma recognition procedure both for Slovenian students who want to study abroad and for foreign students who want their diplomas to be recognized in Slovenia. In total 8 representatives from all four universities in Slovenia participated in the workshop to share their experience and benefits with the DE4A cross-border procedures. Their main benefits were described above in Section 3.2.2.

4.2.3 Spain

The student office and the international relations office in UJI were contacted to request volunteering students to perform controlled tests outside of the official enrolment periods, in coordination with the internal development team. Despite it had been requested to identify incoming students from the other participating Member States, to check if they were eligible to perform production tests or, if they had already spontaneously used the DE4A data retrieval, to survey their experience, both in the dimensions of usability and acceptance, none could be found. The dissemination of the pilot has gone through the common internal channels (meeting with other units/executive level representatives, publication on the internal newsletter) and has been presented to national (informally, several times to the NREN) and international IT and education congresses: planned contribution to upcoming NREN congresses could not be achieved due to not being retaken yet after the pandemic, but participation was possible in the EUNIS22 international IT and education congress, where the pilot design and development, as well as some interim results and expectations, were presented, and registered as a paper on the congress proceedings.[16] Administration staff at UJI was also interviewed for their feedback on the improved procedures.

4.3 Pilot governance and internal progress reporting

This subsection outlines how the DE4A pilots' governance, proposed in D4.2, was executed. The main goals of the pilot governance were:

- Continuous supervision of pilot activities to ensure the execution of the pilots was aligned with project target outcomes and expected impacts. To achieve this prompt reaction to any issue was necessary as well as advisory support to the follow-up of preventive measures. This monitoring facilitated the fulfilment of the Executive Board duties (bi-weekly) which have been periodically reported as well monthly to the decision bodies of the project (i.e. MS-Council).
- Adequate and timely management of either those situations common to the three pilots requiring a common direction across them (Pilots Coordination with weekly teleconferences between Atos and the Pilot Leaders) and/or situations that require escalation to higher management levels and/or coordination from Technical Working Group, i.e. they could have a project-wide impact.
- Integrated reporting to the management work package (WP9) and DE4A management and decision bodies including the Project Coordinator and the Member State Council.

Effective coordination within the pilot management level was provided by the pilot supervisory team (PST), consisting of the pilot leader and representatives of each of the partners involved in the pilot. The PST meetings were the current regular weekly pilot meetings where all pilot partners were

[16] https://easychair.org/publications/volume/EUNIS_2022

participating. In the meetings, internal decisions were taken on the pilot, continuously assessed the running of the pilot online services and ongoing activities of the running phase, and agreed on the problems that needed to be raised to the DE4A Technical Working Group and the DE4A Executive Board. Project partners not officially participating in the pilot but involved in the implementation of the common infrastructure (e.g. the partners responsible for the national connectors) were also invited to some of the meetings. The PST was chaired by the pilot leader. Due to the small number of people involved in the pilot, it was not necessary to set up special internal groups.

In terms of pilot governance, the Executive Board supported the management of the operational activities during the live running of the pilot as a decision-making body guided by the information provided by the PST (represented by the Pilot Leader).

The Executive Board is chaired by Project Coordinator (ATOS) and the conference call is every two weeks. Minutes are produced after every teleconference and the MS-Council is informed or asked for support for especially critical issues as well, based on the Executive Board conclusions when needed.

Cross-WP technical issues were resolved at weekly meetings of the Technical Working Group (TWG), where all pilot leaders, leaders of technical working packages (WP2, WP3, WP5), the pilot coordinator, and the TWG leader participated.

In advance of new DE/DO or Issuer/Verifier combinations where student data were used, the privacy measures as defined in the Memorandum of Understanding (MoU) were checked and enforced, and the Data Protection Officer (DPO) was informed. No issues existed during the pilot runs, that required any intervention from the DPO.

Before the launch of particular combinations, a press release was made available on the DE4A website.

4.4 Knowledge exchange among pilot partners

This section briefly summarizes how the pilot partners exchanged knowledge they gained from running the pilot. There were six main channels to exchange knowledge among themselves:

- Regular pilot meetings where a wide variety of issues and aspects to coordinate were addressed,
- Connectathons with a direct discussion of technical issues and bug troubleshooting resulting from Playground and cross-border testing,
- pilot e-mailing list,
- Owncloud (project internal repository),
- Slack channels, and
- Public Wiki[17].

Pilot meetings were organized every week to discuss the pilot progress and share experience with the common components, DEs, DOs, Verifiers, and Issuers.

Between the meetings, the pilot and project e-mailing lists were mainly used as well as various Slack channels focused on different patterns and the DE4A connector. Owncloud served as the main document repository to document gained knowledge. Wiki was primarily used to describe the three use cases, pilot objectives, as well as the status of endpoints and cross-border interoperability status.

4.5 Stabilisation of pilot experience and user support

Participating guidelines and the Frequently Asked Questions section were regularly updated on the Studying Abroad pilot microsite (https://www.de4a.eu/studyingabroadpilot). Frequently Asked Questions, for example, help the students to understand the goals of the pilot, who and how can

[17] Wiki served to exchange technical Information between partners, some examples of pages for this are https://wiki.de4a.eu/index.php/Useful_information_on_pilots_and_participants and https://wiki.de4a.eu/index.php/Studying_Abroad_Pilot

participate in the pilot, and where to get a valid eID and a DE4A digital wallet for a mobile phone. For each launched service, a walkthrough was prepared that demonstrates the service use and published on the microsite. Supervised students were also given support during piloting by their supervisors if needed. Optimised VC flow in UC#3 reduced the number of interactions with the procedure and evidence portals and improved the user experience of the students.

4.6 Suggestions for extended functions post-pilot

All university representatives appreciated the benefits that DE4A procedures bring to the enrolment of foreign students and diploma recognition. On the other hand, based on their feedback, the representatives of student offices in Slovenia would welcome the whole diploma supplement in the canonical evidence structure or domestic evidence. They would also need information on whether the foreign higher education institution is an accredited institution.

When defining canonical evidence for Higher Education Diploma it was found that Europass-EDCI and SDG WG3 use different vocabularies for their diploma models. As described in Section 3.2.3, further harmonization of the evidence structures is desirable considering ongoing initiatives in EHEA and the upcoming implementation of eIDAS use cases in the higher education domain.

Within the time of the final iteration, the revocation functionality was not implemented for the Verifiable Credentials pattern (UC#3) because it was not yet supported by EBSI.

5 Conclusions and major achievements of the pilot

Over the past several months, the pilot partners have updated and integrated various Data Evaluators and Data Owners and established interoperability among all MS participating in the pilot. This document is the report on the pilot activities of the final iteration.

The main results achieved in the final iteration and presented in this report include:

- Several changes and improvements based on the feedback on the design, customization, implementation, and testing in the first iteration were made:
  - support of enrolment to the first Bologna degree studies,
  - extension of a higher education diploma canonical evidence with an average grade element,
  - provision and support of additional DE4A canonical evidence types (proof of completion of secondary education, large family evidence, disability evidence) in UC#1 and UC#2,
  - support of multi-evidence case (multiple evidence types) in UC#2,
  - implementation of a new way of user redirection in UC#1 and UC#2 (USI pattern),
  - implementation of optimized VC pattern in UC#3, and
  - 100% increase of real students piloting the procedures;
- Two evidence exchange patterns (User-supported intermediation - USI, Verifiable credentials - VC) and four DE4A canonical evidence types were piloted with real students;
- Six data evaluators/verifiers and six data owners/issuers have been successfully customized and integrated with the eIDAS infrastructure and the DE4A OOP TS or EBSI infrastructure;
- Interoperability between all three MS (Portugal, Slovenia, Spain) has been achieved. All 12 planned cross-border combinations between DEs and DOs or Issuers and Verifiers were successfully piloted with real students: 6 combinations in UC#1, 2 in UC#2, and 4 in UC#3;
- Various strategies to mitigate infrastructure delays have been defined and applied;
- Feedback on satisfaction with the piloted services was obtained from a total of 104 students via an online questionnaire. The most valued aspects of the piloted procedures (on a scale from 1 to 5) were the duration of the procedures (4.26), control in managing own credentials (4.16), security and privacy protection (4.09), and required effort (4.02), while the least appreciated was the number of errors and interruptions (3.52). Compared to the first iteration, the share of students who were satisfied or very satisfied with the overall experience increased by 10 percentage points to 66%. The majority of the students who provided feedback on the Explicit Request and Preview common also appreciated the clarity of these two functionalities. Students' feedback was used to generate one success story and the results for corresponding pilot metrics in the final iteration;
- Feedback on the benefits of the piloted services was obtained from the university administration staff, such as student office staff. Their experiences show, for example, that DE4A procedures can save significant time in processing students' information, especially in the validation of higher education diplomas, from 20 and 30 minutes per foreign student in the cases of Portugal and Slovenia respectively to up to several days in the case of Spain. The respondents also appreciated the quality of received students' data, especially the correctness and reliability of the data and availability in electronic format. Feedback was used to generate three success stories and the results for corresponding pilot metrics in the final iteration;
- Feedback on the usefulness of the common components and specifications was collected from pilot partners and other organisations involved in the customization, implementation, deployment, and testing of Data Evaluators - DEs, Data Owners DOs, or infrastructure. The institutions highly appreciate the common components, especially the Kafka server (4.40) and the central SMP (4.29) in the playground, and the DE4A connector (4.24);
- Based on the feedback, lessons learnt and suggestions for adoption were gathered in different steps. For the analysis and design phase, the pilot recommends re-evaluation of the scope of the SDG regulation to some higher education use cases, harmonization of the evidence data models defined

separately by SDG WG and Europass, and a temporary solution for the use of non-notified eIDs in SDG procedures. The lessons learnt in the customisation, integration, and testing phase mainly relate to the usefulness of the DE4A connector, the documentation, and the collaboration between the developers.

In addition to the Studying Abroad pilot, the pilot results were also used by other DE4A activities, in particular WP2 – Architecture vision and framework (validation of the project start architecture, the User-supported intermediation pattern and the Verifiable credentials pattern), WP3 - Semantic interoperability solutions (validation of data models for higher education), WP5 - Common component design & development (validation of the common components such as DE4A Connector, SMP/IAL and SSI Authority agent, and the underlying evidence exchange infrastructure - DE4A OOP Technical system and the EBSI infrastructure), WP6 – Sustainability impact and new governance models (business models and new models for shared delivery of common services), "WP7 Legal and ethical compliance and consensus building" (legal outcomes of the final iteration and contribution to the DE4A legal workshop in Q1 2023), and WP8 – Stakeholder dialogue, dissemination and communication (dissemination and communication activities).

Collaboration between several institutions from Portugal, Slovenia, and Spain in the Studying Abroad pilot has proven tangible benefits from the secure, high-quality, and user-centric cross-border exchange of evidence for online Higher Education procedures that will greatly facilitate student mobility in Europe and significantly reduce administrative burdens. The pilot has contributed to the expected DE4A benefits as a project and the external community of SDG stakeholders in several ways. It has validated the project start architecture, the User-supported Intermediation, and the Verifiable Credentials patterns, as well as the canonical model for higher education diplomas. The pilot has also validated the common components such as DE4A Connector and SSI Authority Agent and the underlying evidence exchange infrastructure. Finally, the pilot partners have provided feedback to the SDG semantic working group on the higher education evidence scheme.

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