

# PR4 – Digital learning analytics tool Progress Report

"Improving online and blended learning with educational data analytics"

# "ILEDA"

# Project No. 2021-1-BG01-KA220-HED-000031121



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# 1 General Description of Project Result 4

Development and implementation of activities included in the Project Result 4 (PR4) started in July, 2022. PR4 fully utilized approached and methods of Learning Analytics (LA). The justification and the necessity to carry out the needed development within PR4 are described in the proposal as follows:

"One of the goals of this project result is to compile and adopt existing software tools that can accomplish collection and analytics of learner data. However, existing learning analytics tools are not all encompassing, and does not cover all of the learning analytics needed when introducing and adopting new instructional methods, so adaptations and development of new learning analytics tools will be necessary. Three of the institutions, US, ULE and UEF are using Moodle as their institutional Learning Management System (LMS). For Moodle there are already some available learning analytics tool, but they do not utilize all of the necessary data collection and analysis needed. On the other hand, learning analytics tool for LAMS are rather limited, or rather not existent. Therefore, there is a need for development of compatible tool for all institutions. Similar as in the previous outputs, it is necessary to consider ethical guidelines for collection and usage of learner data, for each individual software tool.

Conduction of pilot courses are second steppingstone in evaluating all of the previous project results. Furthermore, along with previous results and experiences from the pilot courses, will be used to expand the set framework in the next phase, for creation of the guidelines for wider spectrum of courses and teaching areas. Target groups include teachers in higher education institutions, graduate students, researchers, as well as any of the organization whose work is related to education and is interested in implementing different forms of instructional teaching models, along with learning analytics. This result is focused on:

- Designing and developing software tool that collects and provides analysis on student activities using online platforms.
- Compiling and adopting existing software tools for collection and analysis of student activities using online platforms.
- Integration of the designed learning analytics tool with learning management systems (LMS) at each partner university.
- Collection of feedback and system usage satisfaction from teachers and students.

*Results of PR4 will include:* 

- Developed 1 software learning analytics tool that can be used by all participants and will be shared as an open source code for the wider audience (media: Software)
- Collection of existing learning analytics tools that can be integrated with the existing learning management system for each institution (media: Collection) (responsible for the final result: ULE)
- Conducted 8 courses (media: textFiles, Collections) (responsible for the final result: UNISOFIA)
- Collected learning analytics from 8 courses that will be shared as an open dataset for the wider audience (media: Dataset) (responsible for the final result: UNISOFIA)"

PR4 development has been distributed in different activities, some of which have been completed in the project's first year. The distribution of the activities are highlighted as follows:

- Act 4.1. Defining requirements for learning analytics software tool.
  - Define each participant teaching/learning context within the context of LA.
  - Define main metrics that will allow tracking of student progress and that will fit this tracking for pilot courses in each institution.

- Define the technical constraints of each institution.
- Propose a possible software architecture for the technical solution.
- Act 4.2. Compiling and adapting existing learning analytics tools collect and integrate other tools that are available on the market.
  - Propose a template for tools description and a repository to upload the templates.
  - $\circ$   $\,$  Each partner should describe its own LA tools and those they are familiar with.
  - Compile other applicable LA tools looking into the Internet (if possible, free LA tools). Each partner should compile 5 possible tools and fulfill the templates describing details of each tool.
  - Discuss about the tools and adapt/adopt some tools to be used in the pilots.
  - Look for technologies to implement LA tools that could be used independently of the LMS (ej: xAPI) and decide what to use for the development.
- Act 4.3. Defining ethical requirements for the usage of learner data.
  - Propose an ethical guidelines for the pilots taking into account the possible restrictions in each institution.
- Act 4.4. Developing learning analytics software tool. Develop 1 tool that makes possible the analysis of students' progress independently of the LMS. This involves:
  - Define the technology to be used.
  - Design and development of the tool.
  - $\circ$  Tool testing.
- Act 4.5. Integration of developed learning analytics tool with LMS at each PU.
- Act 4.6. Proof of concept of implementation of framework in pilot courses.
- Act 4.7. Analyzing the impact and effects of the pilot courses.

# 2 Description of Act 4.1. Defining requirements for learning analytics software tool

First task was to understand the context of teaching/learning at each partner institution and the current LA landscape. In order to do so, each of the partners fulfilled a Context Template (annexed to the report) that explores the items described in the LA framework specified in PR2 (the whole compilation is available at: <u>https://drive.google.com/drive/folders/1ScGRhZd-5wh9XrR0x5B1HvxWvn9p40Nl?usp=sharing</u>). The Context Template into account

- the technological systems partner institutions employed in learning;
- the available LA Tools; the LA policy;
- the Data Access Policy (if any);
- the Application Scope;
- the Ethical Policy; and
- the Expert Support (if any).

With this information it was possible to find out that:

- 1) Three partner institutions were using Moodle (US, ULE and UEF) and one of the partners was using LAMS (BMU);
- 2) Most of the partners only use the LA tools provided by the LMS and also one of them (ULE) has developed a tool to measure specific competence;
- 3) Most of the partner institutions rules in regards to data privacy followed EU-GDPR;
- 4) Course data is accessible on the institutional computers for the teachers in charge of teaching it;
- 5) The partner institutions did not have specifically designed LA policy;
- 6) For piloting, and as the first step in the development the LA application scope will be on the course level; and
- 7) Expert support is not always available.

In addition to this, the Context Template included a section where each partner was asked to identify what should be assessed in the course and to define several possible metrics. In order to define metrics for the piloting and LA tool to be developed, different partner teaching/learning contexts, the need to follow the framework applying active methodologies and the common indicators the partners considered as essential, were taken into account. Followed by this analysis, following metrics have been defined for the requirements of LA tool:

- Grades
  - Final grade for the course.
  - Checkpoints (to measure percentage of progress taking into account the active methodology applied in each subject).
- Use of resources (video, documents, activities, reading material, etc.)
  - Clicks
  - $\circ$  Time spent
  - Attempts of tests (if some of the questionnaires allow several attempts, something common in the checkpoint tests).
- Other
  - Students' login (time of access, login)
  - Session time.

Furthermore, several technical issues were considered:

1) The universities LMSs are not easily open for the integration and usage of new software tools, especially because they are being used by many teachers and students and a tool

failure can have an important impact on the integrity of the system. This implies the need to replicate institutional environments on a testing server and upload copies of the courses so the analysis could not affect the currently running institutional servers.

2) The case of BMU, as they use LAMS, will need a specific development to have a similar solution to the rest of the institutions (this situation is extended in the results of task 4.2).

Given above-described constraints and taking into account that in the proposal the partnership agreed to "Design and develop software tool that collects and provides analysis on student learning activities and is open so that each institution can use it for their learning analytics with institutional learning management systems" it was necessary to define an open and common tool that can be applied in all institutions. In order to do so, the possible implementation needed to take into account a requirement that new tool can be used with different LMSs, and design and develop a solution to be as independent of institutional technology as possible. For this reason, open and standard solution for technical implementation was chosen to be based on the Experience API (xAPI). xAPI is a new specification for learning technology that makes it possible to collect data about the wide range of learner activities (online and offline). This API captures data in a consistent format about a person or group activities from many technologies. Very different systems are able to securely communicate by capturing and sharing this stream of activities using xAPI's simple vocabulary. This technology allows the definition of a tool that can collect information from the LMS but also from other data sources, so using it in a LA guarantees an open solution not only in the sense of open source software but also in the sense of open solution to include new technologies or data sources.

# 3 Description of Act 4.2. Compiling and adapting existing learning analytics tools collect and integrate other tools that are available on the market

# 3.1 Tools Compilation

During the Tools Compilation activity the project partners compiled different LA tools that were applied in the institutional contexts and other potential tools. In addition, partners described different ways in which some of the tools could be employed in the piloting and the way in which they foresaw the new LA tool to be developed. These tools and possible scenarios of usage were defined using the Tools Compilation Template (included in the annex I). The Tools Compilation Template included following information:

- The tool, which should include information about the systems explored by the LA tool (LMS, external tools, databases, etc); the data to exploit and how it can be accessed; and how the tool can be installed.
- Tool goal that should include what this tool is going to measure and report.
- Tool problems taking into account each partner specific context which could be the most important problems to adopt this tool

From the partnership, only ULE had an ad-hoc defined LA tool while the rest use the tools provided by the LMS, all the partners describe these tools. Moreover, each of the partners have compiled 5 more tools that could be used in each institution (the description of these tools is available at: <a href="https://drive.google.com/drive/folders/1-0DdvUqBxcx0m5QZ31zJvUGDYAkuJUJ-?usp=sharing">https://drive.google.com/drive/folders/1-0DdvUqBxcx0m5QZ31zJvUGDYAkuJUJ-?usp=sharing</a>). During the piloting the tools included by the LMS were used, as well as some other tools that were proposed by the team members. A sample of some of the tools compiled can be seen in the annex I. From the study of the compiled tools, the existing technologies, the constraints of each institution and the metrics defined in the previous task, it was possible to propose an approach for the implementation of the PR4 LA tool.

Design, development and implementation is described in the paper [1]:

Conde, M.Á. et al. (2023). Definition of a Learning Analytics Ecosystem for the ILEDA Project Piloting. In: Zaphiris, P., Ioannou, A. (eds) Learning and Collaboration Technologies. HCII 2023. Lecture Notes in Computer Science, vol 14040. Springer, Cham. https://doi.org/10.1007/978-3-031-34411-4\_30

A brief summary of the solution development and implementation is described in the next subsection.

# 3.2 LA Ecosystem Analysis and Design

### 3.2.1 Analysis

When dealing with the LA tool analysis, it is necessary to consider the partners' contextual information, but we should not forget other important constraints related with technical issues about the LMS:

1) The university LMSs are closed to tests of new tools, especially because they are being used by many teachers and students and a tool failure would have an important impact on the integrity of the system. This implies the need to replicate institutional environments on a testing server and upload copies of the courses so that the analysis could not affect the currently running institutional servers.

2) In the case of BMU, where LAMS is used, additional development is needed in order to achieve the solution that can be properly integrated in the defined LA ecosystem.

Taking these technical issues into account, it is necessary to understand the main stakeholders involved in the process and how this process works. These stakeholders are:

- The lecturer will oversee the pilot course in each institutional LMS and should carry out periodic backups.
- The technician that should restore the course's backup in an LMS instance (that we named as ILEDA LMS) defined for the project.
- The decision maker will have a system in which the information can be explored to make decisions for the local institution or related to the information of the institutional members.

How these actors interact with the system can be seen in Figure 1. The LA tool should be able to gather the information from the ILEDA LMS in each institution and send it to a common repository that will provide visualizations of the data to be checked by the decision maker.



Fig. 1. LA Ecosystem BPMN diagram

#### Solution design

The first issue to consider for designing the tool is the necessity to use a specification or standard that allows integrating the different partners' LMSs. This constraint requires making a technological decision that will affect the tool design. In order to do so, the possible implementation needs to use a specification that can be applied to different LMSs and could be, as far as possible, independent of the institutional technology. An open and standard solution in this case would be a technical implementation based on xAPI.

The Experience API (or xAPI) is a relatively new specification for learning technology that makes it possible to collect data about a wide range of learning experiences a person has (online and offline). This API captures data in a consistent format about a person or group's activities from many technologies. Very different systems can securely communicate by capturing and sharing this stream of activities using xAPI's simple vocabulary [2]. This technology allows the definition of a tool that can collect information from the LMS but also from other data sources, so using it in LA guarantees an open solution, not only in the sense of open-source software but also in the sense of including new technologies or data sources. Implementing xAPI requires sending students' data to a Learning Record Store (LRS), "a server (i.e. system capable of receiving and processing web requests) that is responsible for receiving, storing and providing access to Learning Records" [3]. In this case, we will consider a local LRS with the data of each institution and a global LRS with the data of all the partners.

Figure 2 describes how the solution is designed for each partner. In that figure, it is possible to see that each institution will have an LMS testing instance that includes the data of the courses involved in the piloting. Such data will be sent to a local instance of an LRS, where the information will be accessed, exploited and represented. The data in the LRS will be accessed through a dashboard that will provide a specific representation of the metrics to each partner. During the piloting, the LRS local instances will send the data to a global LRS that will compile the information of each local instance so the results among each partner course can be compared. This data should be previously anonymized, so no personal information is associated with the learning evidence outside the local educational institution. The global LRS will include a dashboard that will allow decision-makers to explore, compare, and present the data from the different institutions. We should point out that this scheme is similar for all the institutions except for BMU, who will need to wrap LAMS information and EMS grades following xAPI specification before sending it to the LRS (Figure 3).



Fig. 2. Deployment diagram for ILEDA project LA tool



Fig. 3. Specific deployment for BMU

# 4 Description of Act 4.3. Defining ethical requirements for the usage of learner data.

In order to carry out the pilots and taking into account each institution restrictions about learners' data described in the requirements templates the consortium led by UEF proposed ethical guidelines for the pilots. The points to take into account were:

- 1) Support and Guidance: LA presents a valuable opportunity for partner universities to provide valuable support and guidance to the students.
- 2) Data Protection Regulations: The learning analytics policy fully aligns with the European General Data Protection Regulation (GDPR) to ensure data protection and privacy compliance.
- 3) Implementation Process: The implementation of LA is an adaptable process that evolves through feedback from stakeholders to allow for continuous improvements and refinements to better achieve the intended goals.
- 4) Data Collection: Data collected about students does not serve as official records of their academic achievements or work and will not be used for assessment purposes.
- 5) Transparency: ILEDA is committed to maintaining transparency in the data collection methods, types of data collected, and data processing techniques.
- 6) Consent: Students will be informed about the objectives, limits, and extent of actions taken based on data and LA.
- 7) Validity and Accuracy: ILEDA acknowledges the potential limitations in the data collected and analytical methods. Thus, ILEDA is dedicated to enhancing data validity and accuracy.
- 8) Zero-Tolerance Policy: ILEDA maintains a strict zero-tolerance policy against profiling students based on data related to abilities, gender, race, religion, or socio-economic status.
- 9) Opting out of Programs: While opting out of core data services is not possible due to their integral role in enrollment and record-keeping, students will have the option to opt out of programs or interventions based on learning analytics.
- 10) Data Anonymization: Whenever data is processed, anonymization will be prioritized, and access to students; private data will be strictly limited.
- 11) Protection of Non-anonymized Data: Non-anonymized data will not be shared, transferred, or handled by third parties without explicit consent from the students.
- 12) Ethical Approval: Any usage of data beyond the scope defined by partner universities will require separate ethical approval or informed consent.
- 13) Involvement of Student Representatives: Students; representatives are integral to the process of formulating and establishing policies for data collection, usage, and implementation.
- 14) Informing Students about LA Services: Students will be informed about LA services during the enrollment process and given the opportunity to consent to additional services not covered in this policy.
- 15) Data Handling: Access to and processing of students; data will be subject to regulation and auditing by ethical, legal, and privacy oversight bodies.

All of them were accomplished by the involved partners during the piloting, asking for permission and consent both from the institutions and the students, following the GDPR regulation, anonymizing data and giving transparency about how data is dealt with during the whole piloting process. This policy is complementary to the university's own policies of data analysis, if any. A sample of this can be seen in the informed consent included in the forms that students should fulfill at the beginning of the pilot stage (Figure 4).

#### PLEASE READ CAREFULLY

You are invited to participate in a research study. This form has information to help you decide whether or not you wish to participate—please review it carefully.

#### **Risks and discomfort**

The study collects survey data and therefore, there is no risk of any physical harm. Yet, there could be some discomfort or time spent in responding to the survey questions.

As with any online data collection, there is a risk of data leak or loss. We have done our best to minimize that risk by using recommended methods by the GDPR, secure data collection, and special secured computers.

Furthermore, we will keep sensitive data or identifying information at minimum and once we obtain the data, personal data will be separated, encrypted and secured at a safe place. As such, all data will be completely anonymous in the analysis. So any risk of leak during the analysis will not affect personal data.

#### Benefits to You and to Others

We hope that by the end of the project we will be able to understand how students regulate their learning, understand their motivations and engagement.

#### Your Rights as a Research Participant

There are no grades that may be lost or any effect on any assessment related to this research project.

#### Confidentiality

Your responses to this survey will be anonymized and all identifying information will be removed upon completion. Every effort will be made by the researcher to preserve your confidentiality. For the research to be performed. Anonymous responses – devoid of any identifying information – may be shared with other researchers for the sake of research. Yet, Never published in any identifying way of any individual participant.

Participating in this survey imply that you agree on the terms.

Fig. 4. Informed consent for piloting questionnaires

# 5 Description of Act 4.4. Developing learning analytics software tool.

Once the solution was defined and the decision to use the xAPI specification was made, it was necessary to address the LA ecosystem development, which had to be open source and public, once the project is finished. This development implied several decisions such as: the way in which xAPI needed to be integrated with the LMS, the LRS to use, and the dashboards to use.

In order to make these three decisions, the ILEDA partnership conducted a study about the different possible ways to implement the LA ecosystem. Regarding the integration of xAPI, it was necessary to consider that three of the partners use Moodle and other LAMS for their institutional LMSs. For the former, it was necessary to take into account whether to develop an ad hoc plugin or to use one available in the Moodle plugin repository. The partners decided to use an existing one that met the specification: to be open source and to be compatible with the LRS. More specifically logstore\_xapi Moodle plugin (<u>https://github.com/xAPI-vle/moodle-logstore\_xapi</u>). BMU required the definition of an xAPI Wrapper that could extract information from LAMS and other academic systems in order to build the xAPI statements and send them to LRS.

For the LRS choice, the criteria were similar than for the xAPI integration system, that is, an opensource system, that follows the xAPI specification, and given ILEDA design, it should be built as a standalone solution. With these features, 26 options were studied (see tables 1 and 2 based on <u>https://adopters.adlnet.gov/products/all/0</u>), and the final decision was to use Learning Locker as it fit in with the project's requirements, has a well-maintained Moodle Plugin, and is easy to modify.

LRS	Organizatio n	Description	Link	Languag e	DB	Туре	Comments
Learning Locker by Learning Pool	HT2 Labs	The most widely installed Open Source LRS in the world, Learning Locker is simple to install on your own cloud infrastructure, or you can use our SaaS service. You can be up and running in minutes, for free. Our Enterprise options are designed to help you scale securely to a global audience.	https://learninglocker.net	Javascrip t	MongoDB	Standalon e	Commits are old on Github. Some dependencies are quite outdated

 Table 1. – Eligible LRS for ILEDA Projects

Yet xAPI LRS	YET Analytics Inc.	Collect and analyze activity, learning, behavior and performance. Gain insight into engagement, learning effectiveness, information use and team behaviors	https://www.yetanalytics.com/xapi-Irs https://www.yetanalytics.com/profileto ols https://www.sqllrs.com/	Java	H2 / SQLite / Postgre S	Standalon e	Available on Github Has docker image Quite maintained
TRAX LRS 20 TRAX LRS	Sébastien Fraysse	TRAX LRS is a progressive LRS. You start with a simple, reliable and clean open solution. Then you add features as you grow with your xAPI data. TRAX LRS is developers friendly and relies on a well-known technology stack (Laravel 7, MySQL 8, MariaDB 10.4, PostgreSQL 12).	http://traxirs.com	PHP (Laravel) + Vue	MySQL / MariaDB / Postgres	Standalon e	A bit more maintained than Learning Locker. Less preferred languages. Quote: "Based on the results of the performed tests, one can notice that Learning Locker has, sometimes, the best min and max values for response time. However, TRAX LRS outperforms Learning Locker in all the tests scenarios." ONLY PAID VERSION
ADL Learning Record Store	Advanced Distributed Learning	This is a reference implementatio n of an LRS as described in the experience API specification	https://lrs.adlnet.gov https://github.com/adlnet/ADL_LRS	Python	Postgre s	Standalon e and public version	Reference implementatio n from ADL

LRS	Organizatio n	Description	Link	Languag e	Туре	Comments
LRS.io	Veracity Technology Consultants	The Veracity LRS (Learning Record Store) is a standardized, simple way to collect and analyze performance data. Our	https://lrs.io	?	SaaS or standalone	Free version not enough

		LRS is incredibly easy to integrate and use, allowing you to spend time thinking about your content, not your infrastructure.				
Vovio	E-co e- learning studio	VOVLO is an LRS designed for large corporates. Developed to use the CMI5 standard on different LMS through the use of its API and for all digital applications that use the xAPI standard. It is a ready-to- use SaaS solution.	<u>https://www.studioeco.it</u>	?	SaaS	Not open source
Core LRS	Junction-18 Ltd	CoreLRS is Cloud enabled with a range of affordable plans to host your data wherever you need it. It offers support for eLearning protocols without the need of a third party LMS freeing you to choose where to present your learning. Try our free developer account and be running in minutes.	http://www.coreirs.com	.NET	Standalone	Free developme nt version but otherwise very expensive
LRS Launch	Launch Learning	Go faster with Launch LRS. Experience exceptional speed and security on your own cloud or on- premise infrastructure. Launch Learning can build your complete	https://www.launchlearning.io	?	?	Website not available

		environment for free so you can get started within minutes.				
WWW.corelrs.com	Junction-18 Ltd	For organizations who need a comprehensi ve learner record solution, the CoreLRS is a Learner Record Store that enables you to track and record all learner data from a single solution that supports planet wide scalability.	https://lrs.j18cloud.com	?	?	Old version of CORE LRS
Watershed LRS	Watershed Systems, Inc.	Watershed enables you to track, measure, and visualize the business impact of learning and training across your ecosystem.	https://www.watershedIrs.com/	?	SaaS	Only SaaS not own installation. Free version is limited
UTA LRS	RISC Inc	RISC's LRS is embedded in the award- winning VTA Learning Management System and provides both xAPI and cmi5 support to VTA. Our LRS provides a single storage location for all traditional and non- traditional training events within your organization.	https://risc-inc.com	?	Embedded within LMS	We need standalone!
Meridian LRS	Meridian Knowledge Solutions	Meridian LRS, included with Meridian LMS, supports tracking and analyzing learning data using Experience API (xAPI).	https://www.meridianks.com/	?	Embedded within LMS	We need standalone!

Astute LRS	DeltaNet Ltd	?	https://lrs.astute-elearning.com	?	?	No information !
DELPHIRE Melphire	Boco Digital Media	Delphire is what we call the "non- platform learning platform." This licensed technology requires no huge infrastructure investment and we can have it up and running in weeks. It's the one-stop learning shop for your learners.	https://bocodigitalmedia.com/	?	Embedded within LMS	We need standalone!
VALM MIS Valamis LRS	Valamis Group	Valamis LRS, as a part of the Valamis LXP platform, supports learning technology content standards and specifications the Experience API (xAPI) and Shareable Content Object Reference Model (SCORM) in order to collect data from a wide range of online and offline experiences from a person or group.	https://www.valamis.com	?	Standalone	Not open
SCORM Cloud	Rustici Software	Every free SCORM Cloud account comes with its own built- in LRS. That means you now have a place to send xAPI statements and you can set up your activity providers	https://rusticisoftware.com/products/sc orm-cloud/	?	SaaS	We need standalone!

		with access to your LRS. SCORM Cloud also lets you import and launch xAPI and cmi5 packages as powered by Rustici Engine.				
Rustici LRS Rustici LRS	Rustici Software	Add a learning record store to your learning analytics platform or LMS. The Rustici LRS is an integratable LRS designed to receive, store and return xAPI statements. Forward statements to other LRSs, set up multi- tenant databases, refuse statements and trigger events based on statements received.	https://rusticisoftware.com/products/ru stici-Irs	.NET / Java	Standalone/Sa aS	Paid?? I can't find it explicitly
Rustici Engine Rustici Engine	Rustici Software	Rustici Engine includes an integratable, locally installed LRS that can receive xAPI statements from LMS launched courses and learning activities that live outside of the LMS. It also enables you to send learning records to your LMS, reporting tools and other LRSs. Bonus? Record SCORM data as xAPI.	https://rusticisoftware.com/products/ru stici-engine	.NET / Java	Standalone /laaS	Paid

BRACKEN LRS Bracken LRS	The Tarn Group	Bracken is a digital training platform that gives you the ability to deliver faster, smarter learning outcomes. Our LRS has the ability to host different data and ensures all learning data is located in one place and easy to use.	https://brackenlearning.com/	?	SaaS?	Paid
SABA. Saba Cloud	Saba Software	A complete talent management platform to develop and engage your people.	https://www.saba.com/	?	Integrated within LMS	Paid
<b>EXL</b> hub EXLhub	EXL Inc.	?	http://exlhub.com	?	?	Barely info. HTTPS was not even working
Training Management System	Britannica Knowledge Systems	Fox is an innovative web-based training management system that optimizes the training, scheduling and operational readiness of complex global training organizations	http://www.britannica-ks.com	?	?	?
ONPOINT DIGITAL OnPoint Digital LRS	OnPoint Digital Inc	OnPoint's Integrated LRS works with our primary SQL- based database to collect, analyze and operationaliz e real-time informational services for enterprise learning.	http://mlearning.com	?	?	Paid

GingerApp LRS	GingerApp Company	GingerApp LRS is used for tracking the Experience data of LMSs, Learning applications, Video, etc. It has the total analyzing function by merging with the other data of business systems. Mainly supply in Japan.	<u>https://www.gingerapp.co.jp/index_e.h</u> <u>tml</u>	?	Cloud platform and on-premise	Paid?
	Digital Education Institute	VisCa helps you leverage the latest learning standard xAPI to track diversified and distributed learning experiences.	http://www.visualcatch.org/	?	?	Not accesible
Storepoints Storepoints LRS	Riptide Elements - Riptide Software, Inc.	Track learning activities while collecting, measuring, and distributing learning data and analytics. Now, you can draw direct lines to competencie s and adapt your learning to improve effectiveness.	http://www.riptidelearning.com/	?	?	Not accesible

The LRS was updated to facilitate the use of a more upgraded database version, to include new features, to facilitate the generation of aggregated data (session time based on statements) and to anonymize the information forwarded from а local LRS to the global one (https://github.com/aggeorgiev/learninglocker-docker/tree/ileda). The Moodle plugin also needed some adaption in order to send to the LRS only the new statements, since originally, when restoring Moodle courses (see Fig. 1), the logs were replicated and therefore the same statements were sent again (https://github.com/uleroboticsgroup/logstore-xapi).

The way in which the different components interact can be seen in Fig. 5. It shows that the Moodle plugin installed in the ILEDA Moodle instance of the partners pre-processes students' data by removing duplicates; it builds the xAPI statements and sends them to the local instance of the LRS. The local LRS stores the statements, anonymizes them before forwarding them to the global LRS, and provides local visualizations to be accessed by the institutional decision makers. Finally, the

global LRS receives the statements from each partner's local LRS, stores them, and provides visualizations with the aggregated and anonymized data so as to compare the results from students from the different socio-economic environments.

It is necessary to point out that the type of visualizations depends on the metrics selected, but for the first release they are simple graphs with 2 or 3 variables. They are provided by the Learning Locker LRS and will be improved in future releases of the LA Ecosystem. A sample of the local dashboard, integrated into the LRS, with some visualizations can be seen in Fig 6.



Fig. 5. Activity diagram about the components interaction



Fig. 6. Sofia University LRS Dashboard

Summarizing the development that was carried out can be found at:

- LRS and Dashboard: <u>https://github.com/aggeorgiev/learninglocker-docker/tree/ileda</u>
- Moodle Logstore xAPI Plugin: <u>https://github.com/uleroboticsgroup/logstore-xapi</u>
- LAMS xAPI Wrapper: <a href="https://github.com/jovanametropolitan/ileda-lams-wrapper.git">https://github.com/jovanametropolitan/ileda-lams-wrapper.git</a>
- Graphs for the LRS: <u>https://docs.google.com/document/d/1nGMrZ13V8nV2yi6mRk5jupYSPGmwOKA3/edit?u</u> <u>sp=sharing&ouid=116025676432867078543&rtpof=true&sd=true</u>

# 6 Description of Act 4.5. Integration developed learning analytics tool with LMS at each PU

The integration of the development requires several stages:

 Understanding the main case scenarios during the piloting in order to know how the Learning Analytics Ecosystem was going to be used and integrated. This guide was defined at:

https://docs.google.com/document/d/1nNNe\_9ci5I9Dc5D5KUtczPTstGHFH43l/edit?usp=s haring&ouid=116025676432867078543&rtpof=true&sd=true

- 3) Installing the Local LRS in each local institution. Manual: <u>https://github.com/aggeorgiev/learninglocker-docker/tree/ileda#readme</u>
- 4) Installing the Global LRS in UEF (steps are the same than for the other LRSs).
- 5) Gather data in institutional LMS during the piloting and restore it in local Moodle/LAMS instances, this is done automatically by the developed plugins.
- 6) Forward the data to the Global LRS. Guide: <u>https://docs.google.com/document/d/1nXGBUoDsew1\_4zjwdwjtQrhMpUvU9wLQ/edit?us</u> <u>p=sharing&ouid=116025676432867078543&rtpof=true&sd=true</u>

# 7 Description of Act 4.6. Proof of concept of implementation of framework in pilot courses

During the second semester of 2022/2023 academic year a proof-of-concept implementation of the framework was used during the piloting. Each institution piloted at least two courses one that follows a Project Based Learning Methodology and other that uses Flipped Classroom (in close relationship with developed innovative teaching methods within PR2 and developed teaching materials within PR3). The number of students participated in each pilot course is shown in Table 3 and an image with the students in Moodle per institution in Figure 7,8,9,10, 11 and 12. LAMS information about the courses could be find here: https://drive.google.com/drive/folders/1phWc7GMLOcQ0eUa99w\_zjyU9851Pfycw?usp=sharing

Institution	Course Name	Modality	Number of students that participated in piloting
BMII	Introduction to Programming (Python)	project-based learning	116
BIVIO			110
BMU	Computer Networks	flipped classroom	48
BMU	Computer Organization	project-based learning	88
UEF	Advanced Data Management Systems	flipped classroom	74
UEF	Human Factors of Interactive Technology	project-based learning	170
SU	Human-computer interaction	project-based learning	132
SU	e-Learning	flipped classroom	74
ULE	Computer Architecture	flipped classroom	94
ULE	Web Applications	project-based learning	63

TOTAL

859

🛃 Navegación 📃	Participantes
<ul> <li>Área personal</li> <li>Inicio del sitio</li> <li>Páginas del sitio</li> <li>Mis cursos</li> <li>1742004</li> </ul>	Coincidir Cualquiera 🗢 Seleccionar + Agregar condición
> 1742006 ~ 0709020 ~ Participantes	94 participantes encontrados Nombre Todos A B C D E F G H I J K L M I
Anotaciones MIGUEL ÁNGEL CONDE GONZÁLEZ	Apellido(s) Todos A B C D E F G H I J K L M
Competencias Calificaciones General CHAPTER 1 FUNDAMENTALS OF	Nombre / Apellido(s) Apellido(s) Apellido(s)

> Mis cursos > 0709020 > Participantes

Fig. 7. Computers Architecture and Web Applications Participant Lists (ULE)



Fig. 8. Web Applications Participant Lists (ULE)

moodle English (en) 👻		🜲 🙍 Атанас Георгиев 风 👻
Проектиране на ч Dashboard / Courses / Бакалаври, летен с	ОВЕКО-МАШИНЕН ИНТЕРФЕЙС, ЛЕТЕН СЕМЕСТЪР 2022/2023 еместър 2022/2023 / СИ / Проектиране на човеко-машинен интерфейс, летен сем / Participants	
Administration Course administration Edit settings StrikePlagiarism.com Users	Participants Enrol use Match All   of the following:	Search forums Search Q Advanced search Q
Enrolled users     Enrolled users     Enrolment methods     Groups     Permissions     Other users     Paulk enrolments     Pulk unenrolments	Match     Any     Roles          Type or select.         ▼         Student ×         Student ×	Latest announcements Add a new topic 9 юни, 1642 Олек Константинов Финалии общи оценки (от проектите + теста) Older topics
<ul> <li>Filters</li> <li>Reports</li> <li>Gradebook setup</li> <li>Outcomes</li> <li>Badges</li> <li>Backup</li> </ul>	Add condition Clear filters Apply filters  Apply filters  Apply filters  First name As A B C D E F G H I J K L M N O P Q R S T U V W X V Z	Upcoming events There are no upcoming events Go to calendar
	Fig. 9. Human Computer Interaction Participant Lists (SU)	

moodle English (en) *		🌲 🍺 Атанас Георгиев 🔘 🔹
Електронно обучени Dashboard / Courses / Бакалаври, летен семес	10, ЛЕТЕН СЕМЕСТЪР 2022/2023 пър 2022/2023 / Избираеми дисциплини / Електронно обучение, летен семестър 2022/2023 / Participants	
Navigation	Participants Enrol users Match All  of the following: Match Any  Roles Type or select.  Student  X	Calendar 10101 2023 Mon Tue Wel Thu Fi Sat Sun 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Моге     Соитвез     Свыханаври, летен семестър 2022/2023     Ад     МИ     МИ	AND Match Any    Status	
> КН > И	74 participants found	



	Course	Settings	Participants	Grades	Reports	More 🗸		
Enrolled users \$	Enrol users			_				
Enrolled users								
		_						
Match Any   Select	•	\$						
Match Any  Select Add condition	t 4	•						Clear filters Apply f
Match Any  Select Add condition 251 participants found		•						Clear filters Apply f
Match Any  Select Add condition 251 participants found First name All A B C D	E F G H I	• I J K L	M N O P	Q R S	T U V W	/ X Y Z		Clear filters Apply t

Fig. 11. Human Factors of Interactive Technology Participants List (UEF)

	Course	Settings	Participants	Grades	Reports	More 🛩		
Enrolled users 🗢	Enrol users							
Enrolled users								
Match Any + Selec	ct	\$						8
Match Any  Select Add condition	ot	\$					Clear filters	Apply filte
Match Any   Select  Add condition  Add condition	ot	•					Clear filters	Apply filte
Match Any  Select Add condition 74 participants found First name All A B C 1	D E F G H		M N O	PQRS	T U V	W X Y Z	Clear filters	Apply filte

Fig. 12. Advanced Data Management Systems Participant Lists (UEF)

Each course included in the piloting phase of the project produced several thousands of xAPI statements. Figures 13 shows a summary of the statements for all the courses, figures 14, 15, 16, and 16 are showing sample of dashboards with the anonymized dashboard and statements for each course and institution (a sample per institution is shown).



Help centre Powered by Learning Locker Cloud





Fig. 14. Computers Architecture Dashboard and Statements (ULE).



Fig. 15. Human Computer Interaction Dashboard and Statements (SU).



Fig. 15. Human Factors of Interactive Technology Dashboard and Statements (UEF).



Fig. 16. Computer Organization Dashboard and Statements (BMU).

With all these statements we obtained the results shown in Figure 17 It includes the statement of the institutions.





With these anonymized statements obtained during the piloting a Dataset has been produced. This dataset (available here: <u>https://drive.google.com/file/d/1NmJCl2ksy\_jELujgA\_I-</u>

<u>1J20rwuVUiCz/view?usp=sharing</u>) includes a total of 307739 tuples with the following structure:

- \_id: Unique identifier for each entry in the LRS.
- **id**: Unique identifier for every row (event)
- **timestamp:** Instant in which the event occurred.
- **actor.name:** stakeholder unique identifier
- **verb.id:** id for the type of event (registered, view, completed)
- **verb.display:** understandable name for the event.
- **object\_id** id of the object affected by the evento.
- **object.definition.name:** understandable name of the object.
- **object.definition.type** type of statement.
- **context.taxonomy:** name of the context where the evento take place.
- **result:** string describing the result if any (it includes raw grade, max, min and scale)
- **result.score.scaled:** scaled grade
- **result.success:** description whether if the event is considered as a success or a failure.
- **result.completion**: description if the event has been completed or not.
- **institution:** institution where the event takes place.
- **course:** course in which the evento takes place.

# 8 Description of Act 4.7. Analyzing the impact and effects of the pilot courses

This activity comprised of defining questions for the evaluation of students and teachers feedback about the piloting, as well as collection of their inputs at each institution and for each pilot course. Two different forms were used to gather it.

A sample of the students feedback form can found on the following link: https://docs.google.com/forms/d/e/1FAIpQLSfAqFSU6QOfxoGVP1J8I0FExM9c70lbRPeSKhXvrP BHReqCkg/viewform. In the student questionnaire students were asked about overall satisfaction with the course and the methodology, materials, motivation, etc. Figure 18 shows a screenshot of one of the survey forms.

Feedback Questionnaire
Please fill out the questionnaire considering your experience in attending the Computer Architecture course that implemented this semester flipped classroom learning methodologies.
Anonymous responses – devoid of any identifying information – may be shared with other researchers for the sake of research.
Participating in this survey imply that you agree on the terms.
Please rate your overall satisfaction with the implementation of flipped classroom/project-based learning methodology in the course you participated in
Strongly Dissatisfied
O Dissatisfied
O Neutral
Satisfied
Highly Satisfied
How effective do you feel the flipped classroom methodology was in promoting your learning experience?
Texto de respuesta larga

Fig. 18. – Sample of Students Feedback Form.

The surveys and the results obtained can be downloaded here: https://drive.google.com/drive/folders/1m HcNIC-gZ4sHknKSfYVyEy-

<u>wp\_GMbZ?usp=drive\_link</u>. The discussion and deeper analysis of received feedback is part of PR5, and hence, is not included in this report.

Similar as students, teachers also provided their feedback, but in a different form. A sample of some of the questions can be seen in Figure 19 and the survey and results can be accessed here: <u>https://drive.google.com/drive/folders/1XoZADLtrijSXULgOwrMfZSIHD\_VJUPGq?usp=drive\_lin\_k</u> and https://docs.google.com/spreadsheets/d/1pWITN1lyGpWrCE6NVtwbIXu87UrPlk5JVJm6WM1uvh

<u>https://docs.google.com/spreadsheets/d/1pWITN1lyGpWrCE6NVtwbIXu87UrPlk5JVJm6WM1uvh</u> <u>4/edit#gid=1545048184</u> Also, the results and analysis of their feedback are described in PR5.

Teachers	feedb	ack qu	estion	naire	
Please state your ar ILEDA piloting.	nswers with re	gards to the te	aching modali	ties you thou	ght during the
Thank you for your o	contribution a	nd involvement	tl		
mcong@unileon.es ௺ No compartido	Cambiar de cu	ienta			Ø
	ED/	4	E c	Co-fun Frasmus+ P If the Europ	ded by the rogramme ean Union
I have participated	d in ILEDA tea boom course learning cours	aching: e			
On a scale of 1 (st with the following approach (PBL an	trongly disag statements d flipped clas	ree) to 5 (stro about your ex ssroom) in you	ngly agree), h perience with ur course?	ow much do piloting the	) you agree ILEDA
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I felt confident and prepared to use PbL and flipped classroom methods in my course	0	0	0	0	0
I was able to			Fig. 29	- Sample o	f Teachers Fe

# 9 Annex I

This section includes images of the templates used and of a sample of each template.

# 9.1 Context Description Template

Project No. 2021-1-BG01-KA220-HED-000031121 ("ILEDA") - <Document Title [Noto Serif 9]>

# 1 Context Description and constraints

[In this section you should describe the context where the LA is carried out and the main constraints]

# 1.1 Technological systems employed

[Describe the technological institutional systems used.

Explanation: Referred to the LMS, educational tools, communication tools that are available for both the teachers and the students. Especially important in this sense is if the tools are not interconnected between them.]

# 1.2 LA tools currently available

[Describe the LA tools currently available for the teachers and institutions managers. Explanation: Depending on the application level and technological educational ecosystem is it possible to have different tools such as dashboards, reporting tools, query tools, etc. It is very important to know what is or is not available in the context].

# 1.3 The institutional LA policy

[Describe the institutional LA policy, if any.

Explanation: If the institution has defined a protocol to track students' progress, teachers' activities, content use and so on. If LA is going to be applied, it is good to know how the university is supporting this or if they are supporting it at all. For instance, we could have an interesting tool to exploit and present the students logs, but if the university does not allow the installation of those tools, it is something we could not apply.]

### 1.4 Data access policy

#### [Describe how data is accessed.

Explanation: The data should be accessible to later possible analysis, so it is necessary to know the data protection law that is going to be applied, what part of the students' and teachers' activities can be stored and how much of that data will be accessible for further analysis, if some data must be analyzed in an anonymous way or not, etc. This policy can be defined at different levels, from the university to European laws passing through local, regional, or national laws. If external apps were used during the LA application, it is interesting to know if the data of those contexts can be analyzed from the institutional one.]

# 1.5 Application Scope

[Describe the application scope of your possible LA approach.

Explanation: As in the methodological part, the LA application requires to know at what level it is going to be applied, from an institutional level the learning analytics aims could not be the same as at a course or an activity level. This could be needed for looking at other metrics or to explore metrics in order ways. For an institution it could be interesting to check the first-year students pass

rate, while for the first-year teachers, they could be interested in how this rate is related with the hours spent in the platform.]

### 1.6 Ethical policy.

[Describe your ethical policy if any.

Explanation: Sometimes, it is not considered ethical to use students' information or track what they are doing. This used to be defined at an institutional level. If some of the data could not be used because of ethical reasons this should be considered, specially at the beginning of the application of LA.]

### 1.7 Expert support.

[Describe if you have expert support both for the access or the analysis of data.

Explanation: It is convenient to know if there is some technical team that can support the teacher in accessing the data, generating reports, or installing LA tools. In addition, it is desirable to have a team with a data science background that can help the teachers to understand or to better explore the data.]

# 2 Metrics

[Something essential in LA, once we have defined our aims and the application level is to establish which metrics we are going to attend to. This depends on the previous factors and could be related to other metrics. In order to fulfil this <u>section</u> we recommend to answer the following questions:

- 1. What we would like to assess?
- 2. What information is available to do this?
- 3. What tools or algorithms can be used to analyze the data I have?
- 4. How can we represent the metrics?

For instance, we could decide to assess students' progress, first is to define what we understand by students' progress, later on to check what data do I have available. With the data we can decide the kind of analysis to carry out, but it would be necessary to check in the literature how effectively to track students' progress. With this clear metrics are almost defined, but the representation is also a relevant issue. We should be able to check the students' progress with simple graphs and if possible, at a glance

Once we have the metrics defined, if they do not work properly we can refine them].

# 3 Possible technical solution

[Describe in your opinion and taking into account your context features which could be the best technical solution. Please keep in mind that it should be as open as possible as we would like to use it as common approach for all the project partners.

# 9.2 Context Description Template Sample (ULE)

Project No. 2021-1-BG01-KA220-HED-000031121 ("ILEDA") - <Document Title [Noto Serif 9]>

# 1 Context Description and constraints

The context where the LA application will be carried out is the University of León and the courses of Computers Architecture and ... The University of León is a Spanish public educational institution located at the north- west of Spain with 10.152 students in 2021/2022 academic course [17]. Most of the classes are face to face with a small percentage of online learning.

#### 1.1 Technological systems employed

Both for face-to-face classes and for online learning the LMS employed by the University of León is Moodle. It has a log system that track many of students' activities. Some external tools are also provided by the institution such as Google Suite, Office 365, AVIP Videoconference System, Turnitin, etc. Teachers can use other tools for educational activities.

### 1.2 LA tools currently available

Regarding the LA tools, the teachers can use Moodle reports, however although they are quite varied, they provide too much data and not so useful information. The university does not allow the installation of external plugins just by teacher request, they require a further study by the university ICT team. In 2021 the university acquire an Intelliboard Learning Analytic system, but it is not available for all the teachers.

#### **1.3 The institutional LA policy**

Although at the university different teachers use LA techniques and tools there is not a specific and public policy about this topic.

#### 1.4 Data access policy

The university has a data access policy [18] that follows the Spanish Regulation and the EU-GDPR. As in any educational institution, teachers can access to their students' data and to the grades, but students' data must be maintained in the institutional environments where the university is in charge of personal data security and confidentiality. In addition, when a research activity involves students' data, the ethical commission of the university must approve it. With this consent data can be used anonymously and as aggregated numbers. In this case we have follow the rules applied by the institution and <u>also</u> we attend to the ethical policy. We should point out that with external tools the data does not belong to the institution so is each tool which define a data access policy.

#### 1.5 Application Scope

The university has not published LA initiatives for the whole institution, nor it has been applied at Faculty, Degree or Course level. The ones carried out were done in the context of a subject or an activity of a subject. For instance, the CTMTC case has been applied in several subjects of Computer Science Degree, in each of them in a different way. In this case it will be applied to a part of the subject evaluation but also for the use of contents and <u>students</u> progress.

#### 1.6 Ethical policy.

The university has an ethical committee that is in charge of all the ethical initiatives, there are not a specific protocol for ethics related to Learning <u>Analytics</u> but the regional, national, European and international rules and recommendations are followed. In addition, each activity will explicitly publish what is going to do with data, so the students can decline to participate. In the years of application of LA nonstudents decline to complete the activity in which we apply the tools and techniques.

#### 1.7 Expert support.

For this case study the teachers are also experts on programming, so the technical part was not a problem, however sometimes it was necessary the help of data scientists to know what data meant. For instance, to know if some kind of intervention can be associated to an improvement in students' grades, something that is shown in [1].

#### 2 Metrics

For the metrics we will answer the following questions:

- 1. What we would like to assess?
  - <u>Students</u> progress and content use.
- 2. What information is available to do this?
  - LMS logs, students grades, logs from some external tools
- 3. What tools or algorithms can be used to analyze the data I have?
  - Moodle plugins not installed by the institution, external dashboards. Algorithms to show correlations between students activities and allow to notify them.
- 4. How can we represent the metrics?
  - With connectivity graphs, with graphs about the percentage of use, force graphs to show how near to a resource can be the students depending on how they have used it and a color to show their grades.

# **3** Possible technical solution

If a comparison between different tools is required we can look for open solutions such as XAPI that can be used in different LMSs. If the LMS to use is just Moodle Probably it would be better to use the LMS web services layer. In addition it is necessary to use some tool to define the dashboard and provide access to each institution

# 9.3 Learning Analytics Tool Template

Project No. 2021-1-BG01-KA220-HED-000031121 ("ILEDA") - <Document Title [Noto Serif 9]>

# **1 Tool Description**

[In this section you should describe the the LA tool that could be applied]

#### 1.1 Technological systems employed

[Describe the technological institutional systems used. Explanation: Referred to the LMS, educational tools, that are analyzed with the LA tool]

#### 1.2 Data access

[Describe the data available to be exploited and how to access to it].

### 1.3 Tool installation

[How is installed the tool, e.g. as a plugin, as an external tool]

#### 1.4 Is it possible to use in your context

[Describe if it can be used in your context or not]

# 2 What is the tool measuring and reporting

[Something essential in any LA it is to know what it allows to measure and to report]

# 3 Possible problems

[Describe in your opinion and taking into account your context features which could be the most important problems to adopt this tool

# 9.4 Learning Analytics Tool - Intelliboard

# 1 Tool Description

IntelliBoard is a LA tool that provides analytic and reporting services to education communities and institutions that want expanded reporting and analytics for their LMS platform. It

- Track results instantly
- Compare course performance across time and instructor. <u>Analyze activity completion</u> and engagement
- Monitor learning process through multiple reports that identify at-risk learners using YOUR institutional parameters.
- Data security no data is stored outside of your LMS.
- Allow notifications you can schedule reports for when you need them.
- Identifies patterns of learner behavior

https://moodle.com/certified-integrations/intelliboard/

https://intelliboard.net/features

# 1.1 Technological systems employed

[Describe the technological institutional systems used. Explanation: Referred to the LMS, educational tools, that are analyzed with the LA tool] Compatible with multiple LMS platforms

# 1.2 Data access

[Describe the data available to be exploited and how to access it]. LMS log files

# 1.3 Tool installation

[How is installed the tool, e.g. as a plugin, as an external tool]

IntelliBoard is a Moodle plugin, last version 7.0.0 (2022103104), released November 1, 2022, 11:50 PM https://moodle.org/plugins/local intelliboard/versions

# 1.4 Is it possible to use in your context

[Describe if it can be used in your context or not]

Since it uses moodle data, it could be used as a moodle LA tool

# 10. REFERENCES

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2. xAPI solved and explained, <u>https://xapi.com/</u>, last accessed 09/02/2023.

3. Experience API, <u>https://github.com/adlnet/xAPI-Spec/blob/master/xAPI-About.md#partone</u>, last accessed 09/02/2023.