PROJECT FINAL REPORT

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Project acronym: LEA'S BOX

Project title: Tools for Competence-Centred, Multi-Source Learning Analytics

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Dr. Michael Kickmeier-Rust, TU Graz

Tel: +43 664 1359136

Fax: +43 316 873 30602

E-mail: michael.kickmeier-rust@tugraz.at

Project website address: www.leas-box.eu

Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) [2]:

  X has fully achieved its objectives and technical goals for the period;

  ☐ has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  X is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Manag ement) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Dr. Michael Kickmeier-Rust

Date: 17.02.2017

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism and in that case, no signed paper form needs to be sent

[2] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

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Publishable Summary

Lea’s Box stands for a Learning Analytics Toolbox. The fundamental idea of Learning Analytics is to gather data about student characteristics and student performance and to reason over the data in order to gain deeper insight into learning processes, to better understand students’ needs or to enable a forecast of learning outcomes. There is a number of Learning Analytics solutions available, however, many of them are tailored to online learning scenarios where rich data is available. In the very heart of Lea’s Box is the goal of supporting classroom teachers who are operating in situations which are less suitable for data analytics. Formal classroom education is still a data-lean, analogue process and digital data are collected rather sparsely. If they are collected, oftentimes this happens unsystematically and with a multitude of unconnected data sources. Solutions to support teachers and educators in their daily routines must allow for an easy linking of scattered, incomplete, and messy data with the goal of providing a more holistic insight into learning processes, individual strengths and weaknesses, possible competence gaps, and needs. Lea’s Box offers a modular and service oriented solution in form of a central system that allows connecting all sorts of external data sources via a simple open interface as well as the current quasi standard xAPI. The diverse information are linked to competency models and interpreted on a theory-driven basis.

Lea’s Box provides analytics services on the basis of Competence-based Knowledge Space Theory (CbKST) and Formal Concept Analysis (FCA). These frameworks have a long psycho-pedagogical tradition and offer non-numerical, combinatorics approaches to modelling competencies (viewed as atomic units of aptitude), the relationships between them, and their characteristics. On such theoretical foundations Lea’s Box provides structural interpretations of a learning domain (the so-called learning spaces) that identify individual learning states, paths, and prospects. Available data sources, no matter if this is a Moodle course, a learning game, or a teacher’s personal assessment, can easily be linked to the central competence model and serve as evidences for learning progress. The frameworks operate on a stochastic level so that evidences influence the results of analyses and assertions only cautiously. The possibilities of incorrect data interpretations, accidental errors, or lucky guesses by the learners are always considered with certain likelihood.

The results are not only displayed in form of typical dashboard-style charts, but also in form of structural, directed graphs. These visualizations are innovative approaches to visualizing learning analytics that – although being complex to read – hold a multitude of relevant information. Most importantly, Lea’s Box offers Open Learner Modelling (OLM); the results of analyses are not only displayed in multiple and adaptable forms, the method opens the procedures with which the results have been aggregated and calculated to teachers and learners. By this means the transparency and credibility of analyses can be increase substantially.

To provide a surface for the underlying analytics and visualization services, Lea’s Box deploys a web portal that features not only the core functionalities but also a set of handy internal tools for teachers and a comprehensive configuration and administration tool. The functionalities and the design have been elaborated in close cooperation with teachers from European countries. In the course of the 3 year project, the system has been piloted and re-designed iteratively. Pilot and evaluation studies have been organized in the partnering countries Austria, the Czech Republic, Germany, Turkey, and the United Kingdom. The results emphasize the strengths and added values of the innovative approach to Learning Analytics developed by Lea’s Box.

1.1 Summary description of project context and objectives

Smart educationally technologies and features for the personalization of learning are in the focus of researchers, developers, and companies in the educational landscape. There is hardly an e-Learning product or MOOC that is not featuring learning analytics and related feedback to students and educators. Thus, learning analytics and educational data mining are much more than recent buzz words in educational research: they signify one of the most promising developments in improving teaching and learning. While many attempts to enhance learning with mere technology failed in the past, making sense of a large amount of data collected over a long period of time and conveying it to teachers in a suitable form is indeed the area where computers and technology can add value for future classrooms. However, reasoning about data, and in particular learning-related data, is not trivial and requires a robust foundation of well-elaborated psycho-pedagogical theories.

The fundamental idea of learning analytics is not new. In essence, the aim is using as much information about learners as possible to understand the meaning of the data in terms of the learners' strengths, abilities, knowledge, weakness, learning progress, attitudes, and social networks with the final goal of providing the best and most appropriate personalized support. This is what teachers do and always did. Insofar, developing technologies to support teachers in the core business is delicate. However, technology can help a lot when it comes to collecting, storing, interpreting, and aggregating information about learners that originates from various sources and over a longer period of time (e.g., a semester, a school year, or even in a lifelong learning sense). It can support teachers to analyse this vast amount of data, give it educational meaning, visualize the results, represent the learner in a holistic and fair manner, and provide appropriate feedback.

This project aims to continue and enrich on-going developments and facilitate the broad use of learning analytics in the "real educational world." We particularly seek to introduce theory-driven, psycho-pedagogical approaches to learning analytics, to understand context conditions and show stoppers for learning analytics in practice, and to bring suitable solutions into the educational landscape.

LEA's BOX stands for a Learning Analytics Toolbox that supports

- a competence-centred, multi-source formative assessment methodology based on sound psycho-pedagogical models (i.e., *Competence-based Knowledge Space Theory* and *Formal Concept Analysis*)
- intelligent model-based reasoning services
- innovative visualization techniques

… and is tailored to the very concrete demands and requirements of teachers and learners.

LEA's BOX is a small project with a limited scope and a clear focus. The concrete objectives can be summarized as follows:

- advancing the existing solutions
  - of non-invasive, continuous, formative assessment
  - formal, competence-based learner and domain modelling
  - intelligent, theory-based reasoning and interpretation services
  - aggregation techniques for educational data
  - data visualization and open learner modelling
- adjusting the solutions to the requirements of teachers and learners
- closing the loop from collecting data to presenting the results
- delivering a usable and effective toolkit for teachers
- testing the solutions against a huge set of performance data
- applying and evaluating the solutions in a large number of schools and classes

There is a significant and well-established body of work in the field of learning analytics and educational data mining. We will build on the existing achievements and enrich them via two distinct advancements:

(I) Reasoning algorithms and services based on 2 important psycho-pedagogical frameworks:
  - the **Competence-based Knowledge Space Theory (CbKST),** which originated from the field of intelligent tutorial system and extended to intelligent educational games and formative assessment and feedback.
  - the **Formal Concept Analysis (FCA)**, which originated from applied mathematics as an attempt to formalize concepts and concept hierarchies. As a qualitative methodology, it has been successfully applied in a wide range of areas, such as knowledge representation and management, visualization, and data mining and analysis.

(II) Novel approaches to **visualizing activity/performance/achievement data** by utilizing such methods as structural Hasse diagrams, which is rather unusual in this particular field. The ultimate goal is to feed a broad spectrum of educationally relevant information back to the involved stakeholders (mostly teachers, but also students, administrators, and even parents).

As of the original plan (description of work, DoW) the tangible result of the project is an online portal for teachers and learners which will:

- **provide links to the existing components and interfaces to a broad range of educational data sources**. This way, teachers will be able to link the various tools and methods that they are already using in their daily practice and that provide software APIs (e.g., Moodle courses, electronic tests, Google Docs, etc.) in one central location.
- **implement a set of existing tools** and Web services to provide an initial set of functions for teachers. These components will support activity tracking, domain modelling, or visualization of educational data. The components will primarily originate from the consortium's portfolio of existing developments, tools, and products.

- host the **newly developed LA/EDM services**, empowering educators to conduct competence-based analysis of rich data sets. As indicated in Figure 1.1, we will develop modular components to filter, streamline, and aggregate data from various sources, to analyse and interpret these data, and to store them safely. This will be accomplished in the context of WP3. Special considerations will be made with regard to data protection and privacy requirements. The set of modules and services and data streams will be controlled by a superordinate component, the central executive.
- provide teachers and learners the existing and newly-developed **components for data visualizing** and reporting the results of the analysis. The special research focus of the project is to develop network and lattice-based techniques, such as Hasse diagrams, adapt them to the level of understanding and the expectations of end-users, and apply them for the user-model negotiation.
- provide **interfaces and links to export/report data** and to transfer them to external tools, such as the **OLM platform** of UoB, ePortfolios, or learning management systems.

The following figure illustrates the initially planned system architecture. This architecture has been revised and extended during the project to meet the concretely identified demands of teachers.

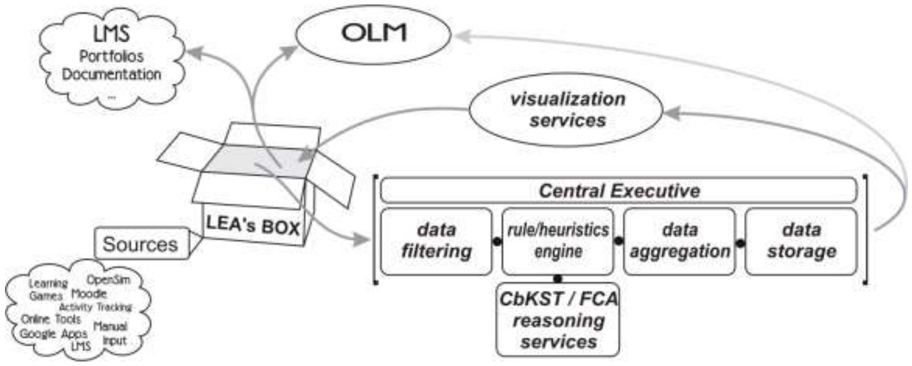

Figure 1. Sketch of the envisioned global system architecture.

1.2 Main S&T Results and Foregrounds

Although Lea's Box is a small project composed of 2 research partners and 2 application partners, Lea's Box is characterized by a dedicated core team, which made significant progress in terms of the project's main goals and beyond. The following report orders the achievements and results along the project's work package (WP) structure. The first complex covers research and technical development. WP2 is dedicated to develop a central learning analytics system including its technical infrastructure and including a web platform as user interface and entry point for the end users. WP3 develops novel theory-driven learning analytics methods on the basis of CbKST and FCA while WP4 is to deliver the related visualization modules and an open learner modelling (OLM) system. The second complex covers the efforts of engaging with end users in terms of identifying demands, getting support in the design, and in piloting and evaluating the developments (WP5). A third complex, the dissemination activities and the means taken by the project to exploit the results (WP5), are described in the subsequent impact section of this report.

WP2 – Platform Development

Lead partner: TUGraz

The main aim of WP2 is to design and develop an easy to use learning analytics web platform for teachers and to equip this platform with the fundamental functionalities. Based on the user studies from the early project periods and the resulting reports as well as a detailed system design documents, an entry point for educators that hosts existing and newly developed LA tools was developed and released. This platform has been revised and adjusted to the needs and expectations of users.

In years 1 and 2 of the project we planned, designed, and released a web platform including an underlying data structure, a user -friendly user interface, as well as various tools. We also established d a first set of APIs for the system. Based on all our experiences with teachers and students, as well as on the basis of feedback from advisors and the scientific community, we substantially revised the entire technological platform, the data treatment, as well as the user interfaces across the entire project. As a result, Lea's Box released a neat web platform that covers the functionalities of the entire system and that serves as a user interface for all components and analytics services. This platform, however, is intended to by a prototype to grant users access to the system features. In future applications, it is unlikely that the platform as such will be used but rather the modular, service-based analytics features. Nevertheless, the portal still serves as a fully functioning entry point for further direct exploitation of the project's results.

In the course of the project, also the originally planned system architecture has been revised an extended. On the basis of our exchange with real end users and the focus group work, the original architecture (cf. Figure 1) had to be changed (cf. Fig. 17). Specifically the API functionalities had to be extended to be able to connect as many external data sources as possible and we had to instate a complete new data structure and a related data analysis warehouse to increase the computational speed of analyses. The final and powerful architecture of the entire Lea's Box system is shown in Figure 3.

Figure 2. Screenshot of the homepage of the Lea's Box web platform.

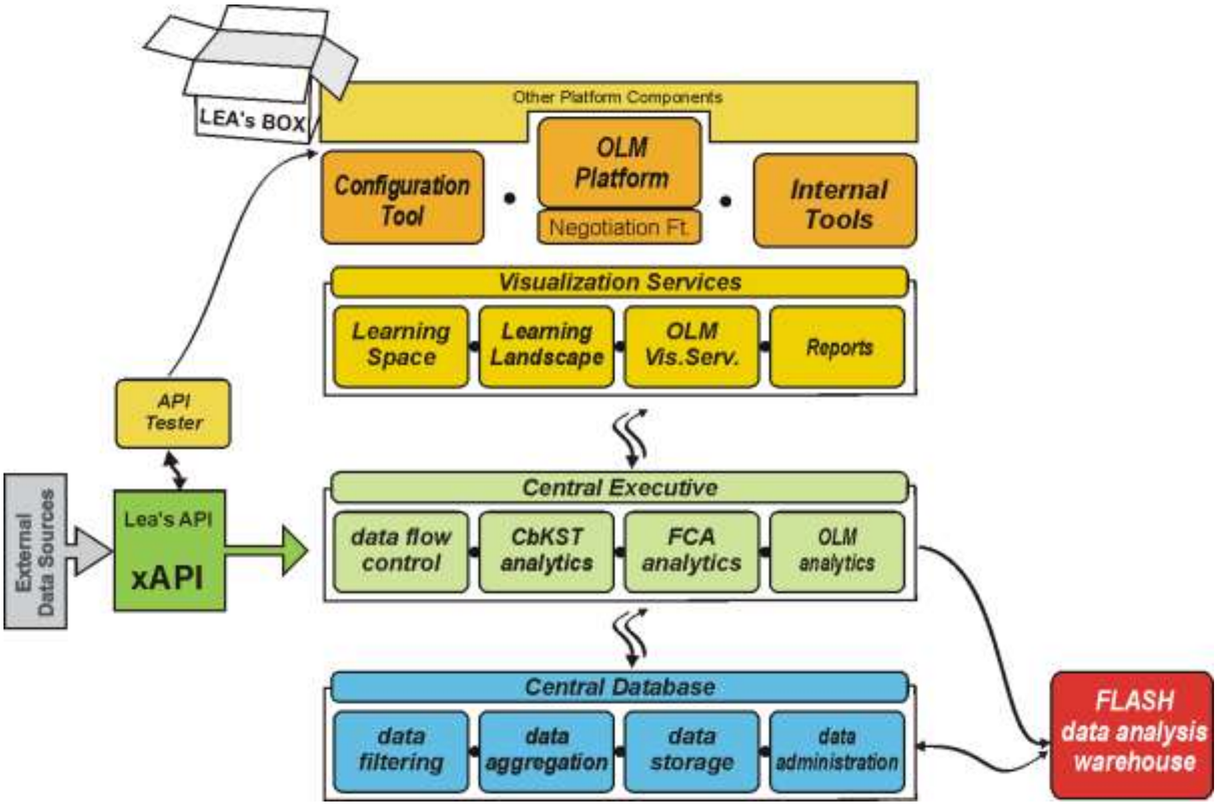

Figure 3. Final System Architecture.

Lea's "Box" is the user interface which is designed to be very simple and intuitive. This platform features various needful tools including myClass for competence tracking, myActivties for recording certain activities (such as homework or assignments), the FCA tool, the flower tool, and testing tools for the API connections. This platform, in addition, grants access to the student and teacher views of the OLM system, it provides a comprehensive configuration tool, and other useful elements (e.g., the mind mapping tool or training materials). The following figure provides some screenshots.

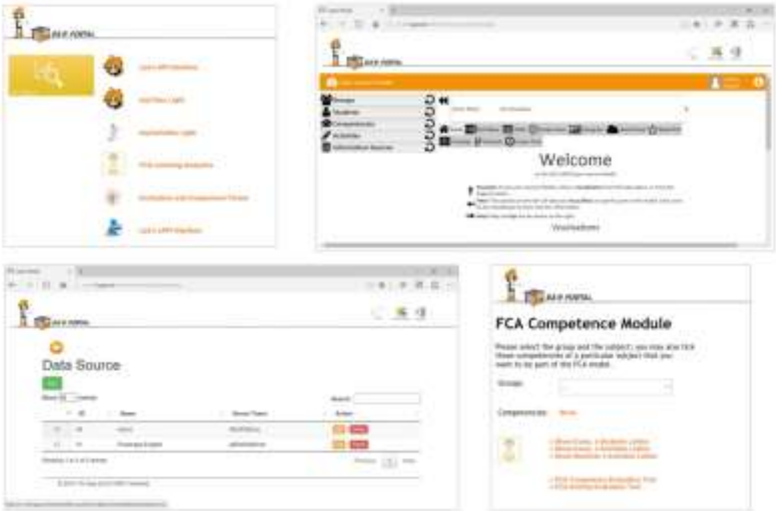

Figure 4. Screenshots of the Lea's Box platform.

The second set of interface components includes the visualization services. Lea's Box features a number of such modular and loose web services for displaying and reporting analytics. This includes the Hasse diagram visualizations, the Learning Landscape, basic reports, and – most importantly – the OLM visualization services.

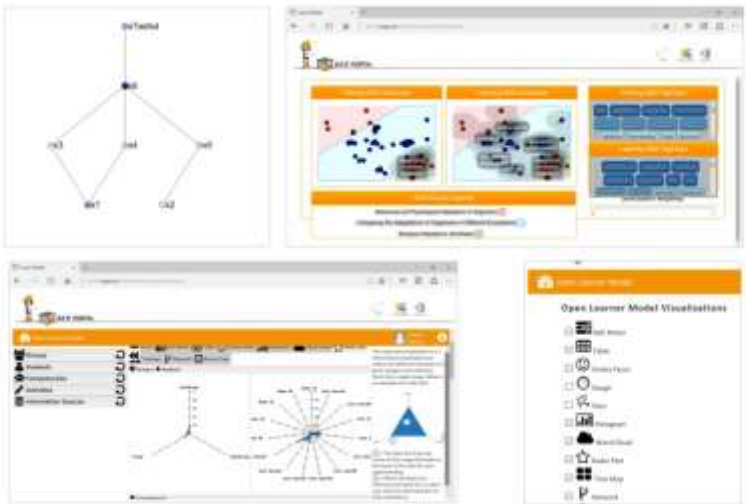

Figure 5. Screenshots of the Lea's Box platform.

The surface components allow users access to the tools and functions. The main analytics system that includes the theory-based algorithms of Lea's Box operates in the background (indicated in green colours in Figure 3). This layer includes the so-called central executive which is the part the controls data flow and analyses on the top level. This software engine triggers the analytics and data maintenance components and established the communication between the various modules and web services. The main elements are a data flow controller to assure that the other modules have access to the right data, the CbKST and FCA analytics algorithms including the LPV prediction algorithm and it includes the functions for the OLM-type student modelling (which is separated from the visualization services). This central component also includes the APIs (Lea's API, xAPI) into the system as well as data export features.

A next level covers the central data model and database system (indicated in blue in Figure 3). Perhaps one of the very important outcomes of the project is the central data model and the related database. This model is highly flexible and can accommodate a very broad range of needs. The data logic is based on 3 major concepts: the students who are flexibly arrange in 'groups', the competencies which are assigned to 'subjects' and evidences (indicators for achievements which are summarised in (internal or external) 'activities'. On the basis of this data model typical University scenarios, where we most often find a loose set of courses, can be realized but also school-type scenarios, where students are grouped in classes and where the subjects and classes are bound to certain school levels which determine the learning goals. Unlike the University setting, in school settings students proceed within the same class through the various school levels. For an analytics system, it is not trivial to handle such flexible and changing demands.

In comparison to other data driven software, the needs, requirements, expectations of the educational sector, the idea of being capable to link a broad range of external sources to the system, as well as the imperative of computation performance in analysing and representing data, makes it incredibly complex and complicated to find the right data model. The result is the central Lea's Box data model which is mirrored by a data analysis warehouse solution, named FLASH, to guarantee a good level of technical performance and software stability.

A relational database for a joint analysis of all data has been constructed for FLASH. Its main goal is to provide a flexible and lasting infrastructure for gaining insight into data from various and multiple sources. To achieve this goal, the database was planned as relatively simple in structure and with open-ended flexibility. Data to be pushed into the database should be easily identified regarding its origin, whilst remaining cleansed from all attributes that would prevent an analysis with data from other sources. Data for a skill/competency is first pushed into a preparatory table. This can happen from another database at the server or, via a frontend like an app, from a remote source with a connection to the server. In the prep_ table, the data's characteristics are made uniform. The external identifier is saved, so every data element can later be updated or delete accordingly to the events from the source. Also, the external id makes it possible to analyse the temporal process of the changes to an element. An atomic skill or competency can be connected with various layers of super-skills, like concepts, topics, subjects or skill-groups, which themselves are also able to be pushed into the database, should such configuration already exist for the data. The database has successfully performed with large data sets from SEBIT and SCIO, and for the latter this is both from data of entry-tests and also SCIO's online testing system. Analyses developed for the database so far have mainly dealt with temporal and descriptive information.

In addition to the actual platform we developed and delivered 3 distinct tool packages that are on the margins of internal and external tools. Concretely we have 2 slightly different myClass packages. myClass is an electronic class book that enables teachers very easily to make records about learning performance of students and to perform basic analysis. In the course of the project we developed tailored versions for 2 partner schools in Austria and Germany. These two products can be used fully disconnected from the main analytics platform of Lea's Box and are freely available from the project website. The third tool is the so-called flower app; a tool with neat flower-style interface that allows teachers and students to make assessments and compare self-assessment, teacher assessment and test results (Figure 6). We received extremely positive feedback to the tool. Future exploitation activities will focus on making this tool a commercial product (e.g., by adding user-friendly and open configuration functions). Also the flower tool is freely available.

In conclusion, driven by WP2, we designed and delivered a fully functioning analytics system that provides simple tools on the surface and complex analytics in the background. The modules and services developed in WPs 3 and 4 are embedded in this central system.

Figure 6. Screenshots of the "Flower App".

WP3 – Analytics and Data Mining Services

Lead partner: TUGraz

The focus of WP3 was primarily finding solutions to fully integrate FCA with typical statistical Learning Analytics, as well as CbKST-type analyses. Learning styles have also been in the focus of this WP and were addressed though the FCA methodology. Most importantly, we developed a catalogue of potential pedagogical questions and provided possible answers that Lea's Box could give. This catalogues serves as the conceptual basis for the development of analytics functions. This catalogue was subject of evaluation studies described in WP5. We developed a number of analyses based on the Lea's Box data warehouse and, on the more research-based side, developed and advanced approaches such as the CbKST-based Learning Horizon. The concrete achievements are as follows:

Competence-based Knowledge Space Theory and Formal Concept Analysis

CbKST and the FCA originate from different research fields: CbKST comes from the field of intelligent tutoring systems and learner modelling; and FCA comes from the field of applied mathematics, aiming to describe knowledge domains by means of concept hierarchies. However, they share some structural features and a similar set - and order theoretic language. In the case of the FCA, Lea's Box attempts to apply the theory for learner modelling, i.e. for describing learners' current competence- or performance states and how to reach a particular target state.

The work on these two theories, and respectively work on their end-user applications, can be divided into conceptual work and technical development:

From a conceptual perspective, work has been carried out to further investigate the similarities and differences from a set-theoretic and order-theoretic point of view (i.e. structural properties, such as closeness under union etc.). As an additional outcome of this comparison between these two theories, FCA has been applied for learner modelling by considering students and competences or performance data in the formal context. This approach of learner modelling is purely "data-driven", i.e. the FCAs´ structures (lattices) directly result from the students' performance data. As compared to this CbKST is more "theory-driven" since domain experts (e.g. teachers) define the relations between the competences beforehand. For a more-depth analysis of the comparison, we also included different algorithms of Inductive Item Tree Analysis (IITA), another "data -driven" approach used to identify relations between performance data such as outcomes on tasks or test -items (explorative data analysis). Another conceptual research stream has focused on the identification of pedagogical questions (such as: "what are the next suitable learning steps for a particular student?"), which can be answered by either one of the theories, or by both of them. Finally, work has been carried out to simplify the resulting visualizations based on the two theories, i.e. either concept lattices or competence spaces, with view to making them more intuitive without a loss of information. As an example for showing different suitable learning paths through the knowledge domain Lea's Box utilizes interactive structural Hasse- diagrams.

To drive the research and to achieve the best possible research outcomes, we engaged with leading experts in mathematical psychology and hosted an expert workshop in Graz. This workshop, together with the endeavours across the entire project, lead to novel perspectives and approaches in the context of FCA and CbKST. An article is in preparation and will be published in early 2017 (*Ganter, B., Suck, R., Heller, J., Bedek, M., & Albert, D.: A practical theory for learning analytics*).

From the technical development side, our FCA tool has been incorporated to the Lea's Box platform, on the one hand as an analytics algorithm and on the other hand as visualization service.

We fully implemented a CbKST-based analytics algorithm and we deployed the necessary configuration functions and visualization services. This project outcome is the first fully function, web-based and performant solution to develop prerequisite relations and derive competence spaces. Although the development of a user-friendly and easy-to-use is not in the prime scope of the project,

Figure 6. Screenshots of the "FCA Tool".

we offer a simple solution to establish CbKST-type prerequisite relations through the configuration tool with only a view mouse clicks. From this relationship we offer a one click solution to generate the binary matrices for the relationships of competencies and to derive the entire competence space from that. This is a computational highly demanding and non-trivial task. Insofar, this is certainly one of the most valuable project results.

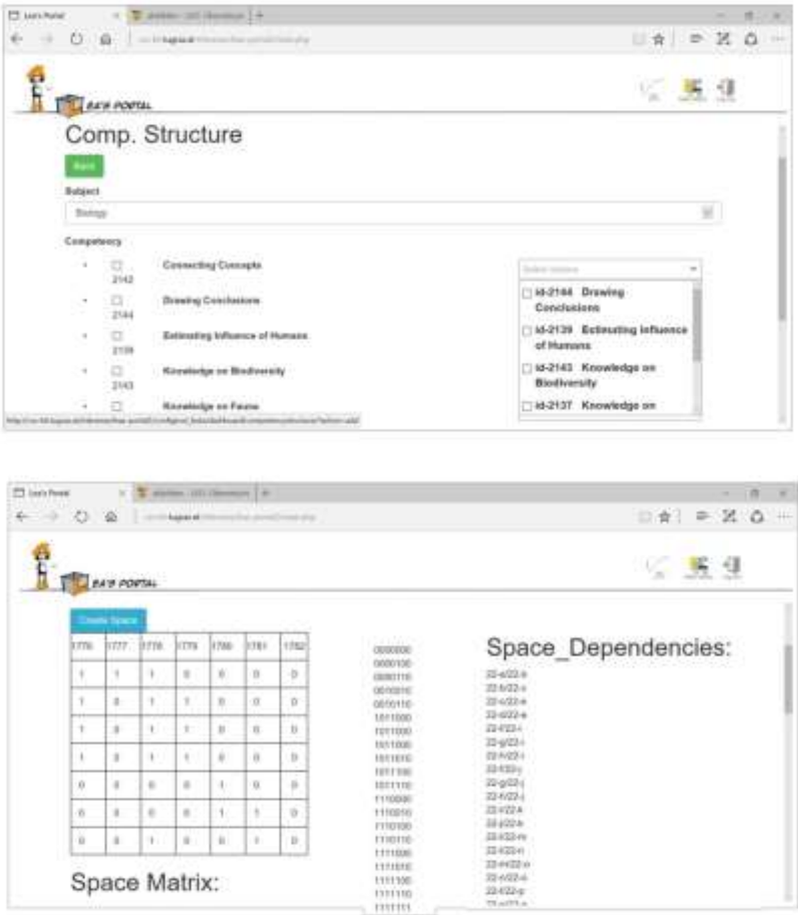

Figure 7. Screenshots of the "CbKST Config Tool".

Learning Performance Vector and the Learning Horizon

A further significant achievement refers to the so-called Learning Performance Vector (LPV) and the Learning Horizon (LH). The structural approach of CbKST allows identifying individual learning paths from the start of a course until the current point in time (the LPV). Based on the so-called outer fringes, we can determine the next possible (in other terms admissible by the competence structure) learning steps and pathways. Taking into account for other relevant factors such as peer performance, the weighting of the complexity of competencies, and the remaining time we can predict a student's chances to reach the learning goal of a course and we can determine in which competency state a student will end up with the highest likelihood (the LH). An in-depth discussion and a simulative study of the LPV/LH approach is reported in deliverable D5.6. The LPV is automatically generated when clicking on a competence state in the Learning Space visualization. The full line indicates to learning path so far and the dotted line shows the LPV prediction. The user can select two ways of calculating this prediction, once using the minimum weights (which corresponds to the easiest possible way to reach a learning goal) and the maximum weights (which is the hardest way).

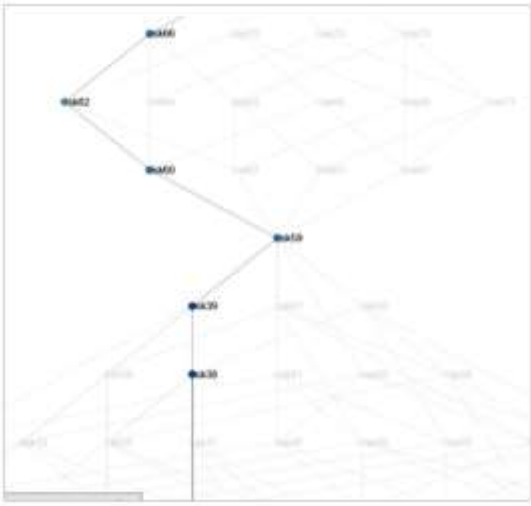

Figure 8. Screenshots of the "LPV Prediction" visualised in the "Learning Space" module.

Learning- and Cognitive Styles

Lea's Box carried out an analysis of the current state of the art on learning styles and cognitive styles. The outcome of this analysis has been described in Deliverable D3.5 (Review article about learning styles and cognitive styles). The research area, literature and empirical results on learning and cognitive styles are diverse, often confusing, and sometimes contradictory. There is a wide range of existing theories and models. Lea's Box has tried to extract the quintessence of the learning and cognitive styles literature by selecting a small subset of rather established accepted models and theories, by describing them and by identifying similarities and differences between them. This identification of such similarities and differences has been done by a FCA. In this FCA analysis we took 70 learning styles (from 13 models and theories) and 48 properties of the learning styles (such as preferred "physical" characteristics of the learning resources) into account. The FCA enabled us to "cluster" the learning styles as well as the above mentioned properties. The results of a corresponding study are described in deliverable D5.6. The results of these efforts will be taken to update and improve one of SCIO's products which is a Learning Styles handbook for teachers.

In conclusion, WP3 achieved the envisaged objectives within the planned resources and made considerable progress. The highlights are the fully function, web-based CbKST configuration as well as analytics and the related LPV method.

WP4 – VISUALIZATION SERVICES AND OPEN LEARNER MODELLING

Lead partner: UoB

Work package 4 comprises three tasks related to the design and implementation of an open learner model appropriate for the project, both in terms of visualisation and interactive maintenance techniques.

Identification, Review and Elaboration of Existing Methods and Techniques

A systematic review of the state of the art in terms of educational data visualisation has been completed. Alongside this work the specification of the OLM in Lea's Box has been extended to more fully encompass the reasons for opening the learner model in the context of the project (e.g. cognition, metacognition, planning, learner autonomy, accuracy). Part of this mandates the consideration that the learner model can be opened from multiple perspectives and that Lea's Box needs to support these. Visualisations to represent multidimensionality and temporal components are made available in the latest release, as a start to realising all the components of this. Furthermore, with view to extending the state-of-the-art, current effort is focussing on producing visualisations that are hybrid competency-activity analytics. That is to say they contain information relating to student competency (as the OLM is a competency analytics tool) but they also make explicit additional information that is actionable in a learning context (e.g. ideas the figure below). Based on focus group work and design workshops several recommendations for the OLM and its visualization services have been provided as user needs. The primary recommendation was to have a visualization that represented the development through time. This recommendation was realized in the "Across Time" view of the OLM. The secondary recommendation was to visualize an easy link between competencies and activities. This recommendation was realized in the "Heat Map" view of OLM. IN addition we added an activity view to provide users with a better and deeper insight into the activities and evidences that led to specific analytics results.

Development of the Visualisation Services

The OLM is now able to display activities. A tool has also been added to Lea's Box that allows competency data to be imported from third party software, such as content management systems, for modelling and visualisation, permitting for a greater number of evidence sources to be included. The visualisation set is extended to include the display of multidimensional and temporal information. Also, the guidance and explanation features that are directly available at the OLM system have been extended and depend. A help section is also included as a basic element for support-to-use, in addition to several online training videos. These are added following engagement and semi- structured interviews with end users.

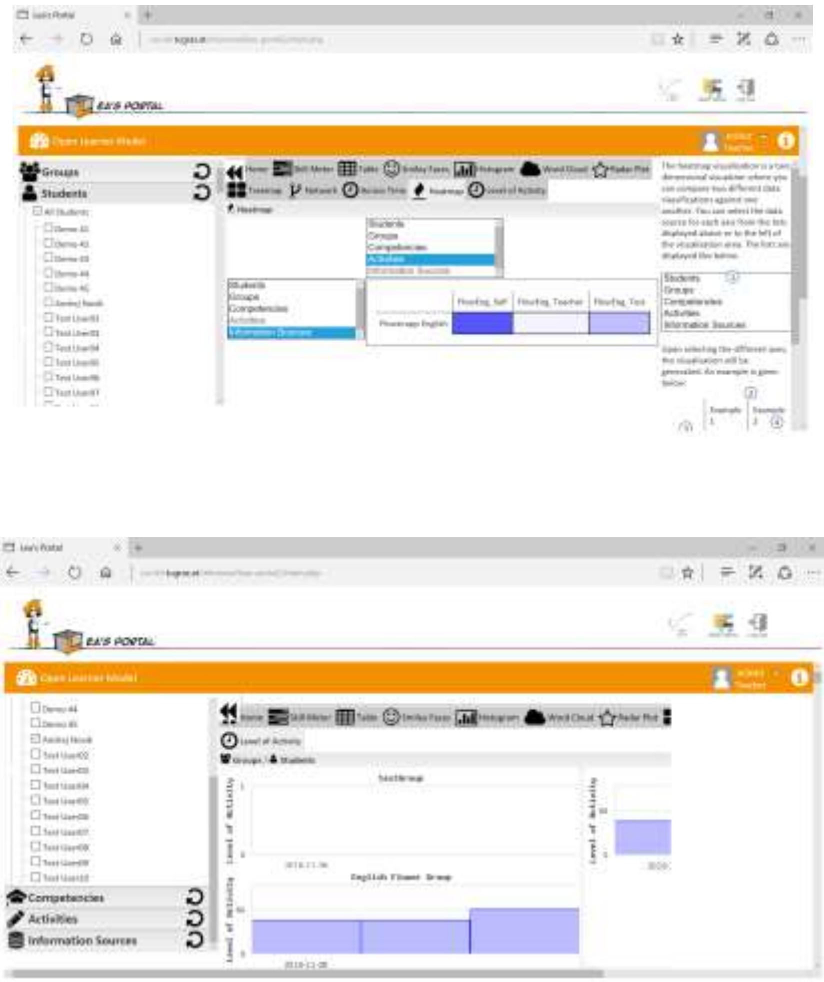

Figure 9. OLM's Heat Map (top) and Across Time (bottom) visualisations.

Load, stress and performance testing has been carried out on the OLM and the OLM as part of Lea's Box, in addition to cross browser compatibility testing. Issues that have been identified have been addressed or a plan put together for their resolution. A basic level of accessibility testing has been completed, including for visual impairment. Interface revisions are made, such as standardisation of colour.

The visualisation libraries that form the back end of main software have been prepared for using open d3 libraries, for extensibility. The data format has also been expanded to allow extra attributes to be sent, including preparing for custom JavaScript activators, to permit more interactive visualisation features. This has completed the preparation work for upcoming visualisation work. The standardisation of the global architecture, that brought all tools into alignment, has been implemented and the API suite has been extended.

Learner Model Negotiation and Communication

These research efforts in the project have identified the key components of design for the implementation of a learner model negotiation facility for the OLM. With the final release the learner model persuasion is successfully implemented and evaluated with end users. A core part of the design is the persuasion workflow (see Figure 10), for an OLM that contains a competency framework. Technical work has been to add initiation points in the interface and to complete a revision of the learner modelling process to take account of the outcome of negotiation/persuasion.

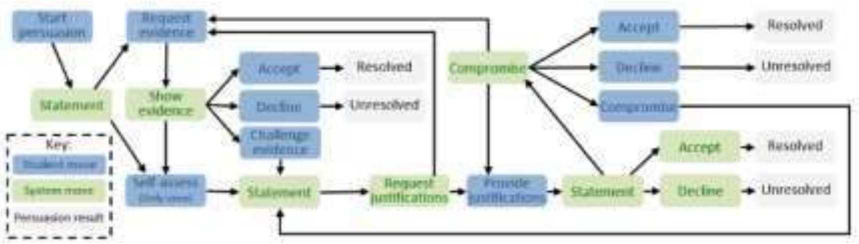

Figure 10. Learner Model Persuasion Workflow.

In addition to the work regarding the OLM system, WP4 is responsible for the technical realization of other visualization services. As described in earlier section of this report, we designed, developed and tested the CbKST-type Hasse diagram visualization service (named Learning Spaces), and the FCA-type lattice visualization service, and the Learning Landscape. In addition, more basic visualization types have been implemented, e.g. for the internal myClass tool, the flower app, and the mind mapping tool.

Overall, in the final project period, the efforts in WP4 were dedicated to the making the services more stable and performant, also we increased a full integration of visualization services with the various tools. A special focus was laid on a smooth data flow through the internal APIs. Thus, WP4 has achieved its planned objectives providing the design and implementation work required for evaluations studies to take place, and completing a good level of preparatory work for the envisaged work.

WP5 – Pilot Studies and Evaluation

Lead partner: SCIO

This has been the final period of Lea´s Box project so herewith we would like to summarize if and how the WP5 activities in general and in the last month in particular helped achieve the achievement indicators as set by the original project plan (DoW, pp. 57-61).

The main objectives of WP5 are:

1. support and contribute to the system design (e.g., via focus groups)
2. apply the developed platform, including its tools and services, in real-world settings and support its evaluation and validation, including providing rich data sets for the RTD activities
3. support a scientifically sound evaluation of certain aspects of the entire system (e.g., usability or validity of LA algorithms)
4. support the dissemination and exploitation of the project and its results, for example, by taking multiplier roles

In general, the work of work package 5 was conceptually divided into two dimensions. On the one hand the dimension of the activity type; we have planned design-related activities (focus groups, design studies) to lay the foundations of the Lea’s Box system; we have planned evaluation studies, focusing on the quality of individual system components and designs; finally, we have planned pilots to see how the solutions work in practice on a higher level. On the other hand, there is the dimension of time: In the first project period, the focus was on supporting system design work, in the second period, the focus was on evaluation and piloting work to provide feedback and enable improvements in terms of design and functionality. In the final year, the focus was on supporting the dissemination and exploitation work. In addition, an aim was to present findings that are relevant for the entire Learning Analytics community.

In the reporting period, these objectives were achieved by two main activity lines:

1. Piloting and evaluation (see Deliverable 5.6)
2. Training and dissemination (see Deliverable 5.8).

Piloting and evaluation

In the third and final year of the project, we focused on evaluating the entire Lea’s Box system.

While in years 1 and 2 of the project, the main focus of evaluation and piloting activities was to design the system and its features and to adjust the user interfaces and functionalities according to the demands of educators. The focus of the final period was on supporting the dissemination and exploitation efforts. Bearing that in mind, the overall goals of the project piloting and evaluation activities were shaped in a close collaboration with training, dissemination and exploitation activities of the project. As this was the final period thereof, we heavily collaborated with our partnering organizations and advisory boards so as to maximize the efficiency while

a) providing the project with information needed for the successful completion (see evaluation matrix)

b) find viable solutions that can directly lead to or facilitate dissemination, exploitation and impact.

In order to be in line with the ethical requirements we increased our collaboration with our project Advisory board where ethical issues were one of the main questions discussed.

In response to the Y2 review we sketched a global piloting and evaluation framework. This framework identifies the relevant system components and specifies the dimensions for evaluation and piloting. For this matrix we proposed priorities for the evaluation activities.

The number of pilots and evaluation studies generally corresponds to the plans, although the time of events sometimes differs from the original plans. Again, the reason is the need to incorporate the organization of the school year as well as real demands and interests into the piloting plan and also a reason is the fact that the original development activities have been delayed at some points.

The main points we focused on during the evaluation phase were functionality and adequacy, stability and speed, usability, effectiveness, reliability and validity, logistical and practical obstacles, feasibility and limitations, and acceptance (based on the general framework).

Key Performance Indicators

The work of WP5 can also be summarized in terms of the key performance indicators as of the DoW. The first numbers before the slash indicate the planned studies or participating teachers as of the DoW, the middle numbers indicate the re-planning as of the annex to the second periodic report, and the number after the slash indicate the actual achievements.

Pilot Studies			
	Country	Nr. of Pilot Studies	Nr. of Teachers
Y3	CZ	2/2/4	3 to 18
	TR	3/2/4	up to 100
	AT, DE	-/3/3	1 to 25

Evaluation Studies			
	Country	Nr. of Pilot Studies	Nr. of Teachers
Y3	CZ	5/5/5	3 to 11
	TR	5/6/7	up to 100
	AT, DE	-/3/3	50

Training and dissemination

Despite of the fact the Lea´s Box is a relatively small project within FP7 standards, consortium partners invested heavily in promoting, disseminating and ultimately training potential end users. This can be seen from the overview of activities carried out during the whole project period. (For details, please refer to Deliverable 5.8).

The project approached training and dissemination activities strategically with the ultimate goal of reaching the best possible impact and with the vision of exploitation of the project outcomes. Also, the training and dissemination activities were not understood as a one-way process. On the contrary, the information and feedback we received from the schools and learners was brought back to the project and helped its further advancement.

Al the activities were aligned along three main strategic goals:

1. Raising awareness (G1)
2. Promoting adoption (G2)
3. Dissemination by early adopters (G3)

In that spirit we dare say that the project has reached most of its dissemination goals as foreseen. As

- the end users in the participating countries became acquainted and more importantly – became aware of the added value that can be provided by learning analytics;
- some of the tools were adopted by participating schools and learners;
- first market implementation of the project outcomes happened already within project timeframe and further collaboration is already planned.

Key Performance Indicators

The number of events that were foreseen in the DoW are given below:

Training and Dissemination Workshops			
	Country	Nr. of Events	Nr. of Participants
Y2	CZ	15	10 to 20
	AT	2	40 to 50
	TR	5	10 to 20
Y3	CZ	10	10 to 20
	AT	2	15 to 25
	TR	5	80 to 100

The activities and events carried out are given below. Noticeably these activities all target eventual exploitation opportunities, especially as a value added service in conjunction with an existing product. There were also various seminars, trainings, webinars, expositions and showcasing events to reach a wide audience in order to attract end-users such as schools, teachers, MoNE, private school networks, school owners and NGOs. The following table lists the most important events, the full list is given in deliverable D5.8.

Event	Partner	Date	Nr. of participants	Participant type	Nr. of events
"Coffee and education" open public discussion[1]on technology in education	SCIO	Dec.14	339[2]	teachers, parents, experts	1
Workshop for teachers involved in Microsoft education centres on Learning and ICT	SCIO	Sep.14	30	teachers, tech-savvies	1
Structured discussions with schools management (all around CZ)	SCIO	Sep-Nov..2015	69	headmasters and their deputies	23
Training sessions for pre-service teachers	SCIO	Jul-Aug.2016	20	teachers	3
Presentation for all headmasters of Prague 6	SCIO	Nov.16	25	municipality, headmasters	1
Training workshops	SCIO	Dec.16	50	headmasters, teachers	6
Symposiums, Conferences, Shows and Events where Learning Analytics was promoted and teachers for focus groups were recruited	SEBIT	March-Dec. 2014	1000+	Academics, Teachers, School Leaders,	9
School visits for dissemination workshops (after requirements were set for the 1st Release of the System)	SEBIT	Winter 2014	50+	Teachers, Headmasters, School Leaders, School owners	3
EBA (Turkish Educational IT Network) Teachers Training	SEBIT	Summer 2015	30	Head teachers, senior teachers of MoNE	1
Learning Analytics presentation at Private Schools Symposium 2015 and 2016	SEBIT	Jan 2015, Jan 2016	3000	All kinds of educators	2
Lecture in Grad Schools of Education (METU, AGU, Ankara, Hacettepe Universities)	SEBIT	METU and Ankara in Spring 2015, AGU and Hacettepe in Autumn 2016	150	Grad School Students who would became future teachers or MoNE personnel	4
School visits for dissemination workshops (after requirements were set for the 2nd Release of the System)	SEBIT	Winter 2015	50+	Teachers, Headmasters, School Leaders, School owners	3

Training mentor teachers of two major pilot studies (lasted 1 month each) in Maya and Ayse Abla Schools	SEBIT	Feb 2016 (Maya) and June 2016 (Ayse Abla)	20	Mentor teachers, Headmasters	1
Training workshop with head teachers during a 2 day workshop	SEBIT	Dec.16	100	Head teachers, senior teachers of MoNE	1
Bildung 4.0 - Training event for teachers (Vienna, full day)	TUG	05.12.2016	25	teachers	1
Teacher Training Workshop Lower Austria (NMS Lilienfeld, Hainfeld, Traisen)	TUG	22.11.2016	17	teachers	1

Summary

Summarizing the results of the activities in WP5, we can say that they revealed concrete evidence that a Learning Analytics support of teachers lead to better achievement, engagement and stronger agency. However, these benefits come with 2 conditions.

Technical perfection and fluency at the first contact with the software are the largest determining factors for the users to adopt analytics frameworks for everyday use. Factors such as an easy URL, easy login, simple use cases, browser support, mobile support affects hugely. The evaluation studies also reveal that peer influence is a great factor in adoption. When students start to talk about the application being “cool” or being “cumbersome,” the idea spreads very easily and becomes a general belief. Part of the project outcome

The second condition is that the learner, teacher, school, community, society has to be ready to let the analytics influence their learning paths, standards, thinking. As we have seen in some of our countries, the residing habits from the past sometimes obstruct the uptake of learning analytics tools. There is a great need for work to be done on reshaping assessment cultures in our countries.

Take-away message

The main message of this report is that Learning Analytics is considered a positive and useful thing. However, the possibilities of this technology must be translated into the very concrete needs, mental models, believes, and concerns of teachers. Also, solutions must be tailored to the daily practice of teachers including the fact that classroom scenarios cannot provide clean and rich data sets for analyses. The understanding and the needs of teachers are different from the solutions and ideas and the thinking of researchers, thus the requested solutions are often much simpler than expected or devised by researchers. Thus, big and complex solutions will fail. In all our experience, teachers tend to prefer simple and clean solutions, even if the ‘power’ of such small solutions is limited. The modular approach of Lea’s Box appears being a highly promising approach to bring the concepts and the ideas of Learning Analytics into schools and classrooms. With a ‘flat’ learning curve’, teachers are curious and willing to dig deeper into the genre and use more and more data tools in their daily practice.

1.3 Potential Impact – Dissemination and Exploitation

(Lead Partner: SEBIT)

The impact such small and short project like Lea's Box can have is clearly limited. The project dedicated a significant amount of effort to dissemination and networking. We tried to address the existing communities of teachers but also decision makers and politicians. In Austria, for example, we closely engaged with the lively eLSA network of ICT-affine schools/principals/teachers. We also targeted the top level policy makers such as Heidrun Strohmeyer the chief of the ICT section in the ministry of education and even the minister of education Judith Hammerschid. Similar activities occurred in the project partner countries.

It is more than difficult, tough, to make claims about the extent to which the project activities had an impact or will have an impact to the mainstream educational landscape. What we can say is that the Austrian government established a fund, equipped with 500M Euros to fund 500 start ups in the field of educational technology. The aim is not only to improve the Austrian landscape, but to make educational technology made in Austria a global success story [1, 2]. Perhaps Lea's Box had absolutely no influence on this initiative, we are visible and will participate and drive this initiative. The time scales to impact in the static educational systems, however, are much longer the project's duration.

In the deliverable D6.5 we outlined a set of important exploitation activities which ascertain that the results of the project will partially be brought into the markets without delays and partially provided to the enthusiastic teachers we found during the project as ready-to-use, open products.

As the work package name implies there were two kinds of activities carried out in WP6. Though the dissemination activities took place evenly throughout the project, the exploitation activities condensed and focused during the last period of the project. This section covers a summary of both, and a bit of outlook beyond the project end date.

The early tasks of work package, namely the project website, print info, project movies, press releases and scientific workshop were all accomplished during the first two years of the project and reported. In fact, not one but 3 project movies were made and not one but four scientific workshops were organized, some of which were in 2016.

[1] http://diepresse.com/home/bildung/schule/5119688/Bildungstechnologie_Regierung-wuenscht-sich-500-Startups

[2] https://science.apa.at/rubrik/bildung/Stiftung_soll_Oesterreich_bei_Bildungstechnologie_voranbringen/SCI_20161117_SCI833059740

Project Website: www.leas-box.eu

The project website was kept active by the coordinator and all the notable events, publications and public deliverables were exposed, firstly, via this web site. There exists links to the Facebook, YouTube and Twitter channels of the project at the home page and to a comprehensive blog page hosted at TUG domain. The blog contains 50+ long articles and accounts of project partners about many dissemination and exploitation events they took part, observe firs hand. Blog articles are published roughly two or three times a month and often shared or reposted via other channels as well. The Facebook, Twitter and YouTube pages of the project are all active channels, with almost daily postings. Each post is frequently shared by project partners penetrating the news and information to a wider public.

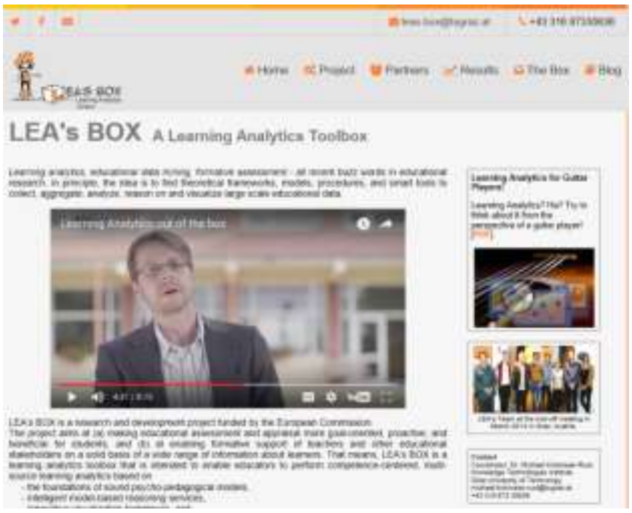

Figure 11. Project Website.

Figure 12. Facebook activities.

It is clear that web communications and specifically communications through social media are the prime channels to reach both scientific and end user communities. Consequently, the project dedicated significant effort on a lively online appearance. Initially we aimed at a Top 10 page ranking, which was quite ambitious. End the end we reached a Top 20 result. Depending on the benchmark method the results vary. For example, the SeoQuake (www.seo.de) statistics as of January 2017 yield a Google index of 194, a Bing index of 57, and an Alexa rank of 32k. When searching for "learning analytics" and adding further defining terms the list rank of leas-box.eu varies strongly. With the terms "CbKST" or "FCA", it appears on the first place, with "OLM" on the 4th (in Bing, as of January 2017). Google Analytics yields 2300+ unique website visitors by January 2017 (see Figure 13).

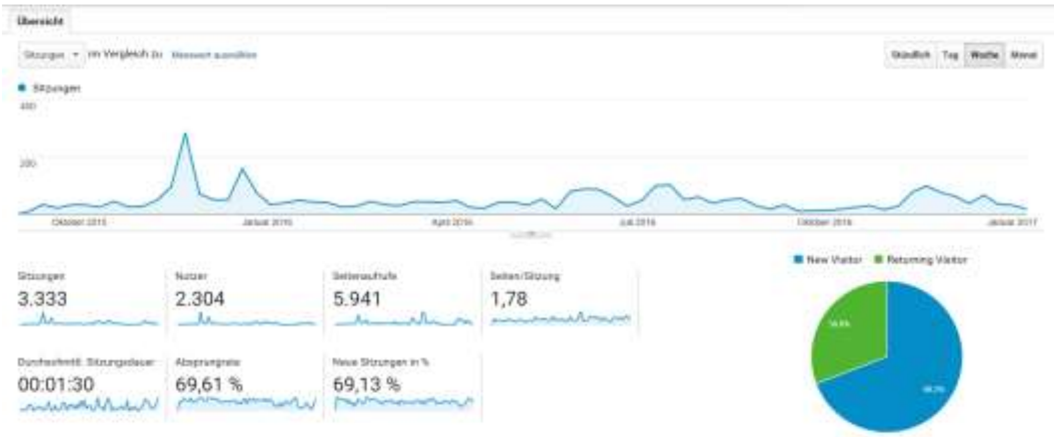

Figure 13. Overview of Website performance by Google Analytics.

On Facebook, we decided not to have a typical corporate account but a personal account of "Lea". The idea is to strengthen personal communications and, most importantly, to be able to follow the communities activities and posts. In total Lea has 116 friends, all part of the ICT / educational technology community and Lea is part of relevant communities (e.g., the eLSA community or the eSchool community). The response rate on posts (3 to 5 on average) is 'nothing' in usual Facebook terms, however, it is quite successful as opposed to comparable Facebook appearances (e.g., by other projects or researchers). The same is holds for Lea's Box YouTube channel, in comparison to other, similar channels, we reach a good portion of people (e.g., 350+ views of the main video).

Figure 14. Lea's Box YouTube Channel.

Figure 15. Info Graphics.

Printed info material

Print info material in multiple languages and in a flyer format have been published in the beginning (M12) of the project based on the functionalities and tools provided by the first release of the system. In addition, an infographic poster was created sharing the project vision and approach to learning analytics and EDM.

There is also a physical paper box of LEA, which usually contains some surprises. This merchandize was made available at every occasion, commemorating the liaisons with the project.

After the second release of the system the print info brochure was updated to emphasize the additional tools.

Press communications / public relations

In terms of reporting the project dissemination activities, there was no discrimination if the activity was a press communication, done for publicity or if it was merely a scholarly communication or else.

There were articles that was services to the press during the launch of the project, later on, there was explicit press coverage as various project activities gained publicity, but specific releases were not made.

Developing a project movie

A number of project movies were created. The first movie was an animation, communicating the general vision of the project. Later movies were shot based on specific scenarios, with professional filming crew and postproduction, showcasing the best practices enabled by the LEA's Box platform.

The videos were made available in YouTube, in the project website and in other channels, including SEBIT's teachers portal where they were viewed 800+ times.

Organization of a scientific workshop

The DoW provisions an international scientific workshop, to share expertise and experience with external experts in the field. This workshop was achieved during the second year of the project and not only served as a platform for exchange but also helped build confidence to facilitate more of such events.

During the project we organized 4 such events. The first was a joint workshop of the GALA Network of Excellence and the LEA’s BOX project at EC-TEL 2014, September 17, 2014, Graz, Austria. Topic was to present and discuss approaches to improve serious games by techniques of learning analytics and educational data mining. The second was a learning analytics summer camp held in July 2015 in Prague, CZ. The forth was the workshop “Learning Analytics for Learners” held in conjunction with LAK’16 in April 2016. Finally, we organized the 4th International Workshop on Teaching Analytics at EC-TEL in September 2016. More information about the events is available through the Lea’s Box website: www.leas-box.eu.

Figure 16. Poster designs of the 4 scientific workshops organized by the project.

Scientific Publications

The following is a list of publications of the project in APA format and alphabetical order. The most important ones are bolded.

Bedek, M., & Albert, D. (2015). Applying Formal Concept Analysis to visualize classroom performance. In proceedings of the 11th International Conference on Knowledge Management, November, 4-6, Osaka, Japan.

Bedek, M., Kickmeier-Rust, M., & Albert, D. (2015). Formal Concept Analysis for Modelling Students in a Technology-enhanced Learning Setting – in: Workshop on Awareness and Reflection in Technology Enhanced Learning, 10th European Conference on Technology enhanced Learning (EC-TEL 2015).

Bull, S. (2016). Negotiated Learner Modelling to Maintain Today's Learner Models. Research and Practice in Technology Enhanced Learning. Research and Practice in Technology Enhanced Learning, 201611:10.

Bull, S., & Al-Shanfari, L. (2015). Negotiating Individual Learner Models in Contexts of Peer Assessment and Group Learning. In the proceedings of 17th International Conference of Artificial Intelligence in Education. Madrid, Spain 22-26 June 2015.

Bull, S., Ginon, B., & Boscolo, C. (2016). Introducing Learning Visualisations and Metacognitive Support in a Persuadable Open Learner Model. In Proceedings of LAK’16, April 25-29, 2016, Edinburgh, UK.

Bull, S., Ginon, B., Boscolo, C., & Johnson, M.D. (2016). Introduction of Learning Visualisations and Metacognitive Support in a Persuadable Open Learner Model. In Proceedings of LAK’16, April 25-29, 2016, Edinburgh, UK.

Bull, S., Kay, J. (2015). New Opportunities with Open Learner Models and Visual Learning Analytics. In the proceedings of 17th International Conference of Artificial Intelligence in Education. Madrid, Spain 22-26 June 2015.

Firtova, L. (2016). Modelling the Relationship Between Learner Autonomy and Cognitive Abilities - Worth the Effort? In R. Vatrapu, M. D. Kickmeier-Rust, B. Ginon, & S. Bull (Eds.), Proceedings of the Fourth International Workshop on Teaching Analytics, in conjunction with EC-TEL 2016 (pp. 30-35). September 16, 2016, Lyon, France.

Ginon, B., Boscolo, C., Johnson, M D., & Bull, S. (2016). Persuading an Open Learner Model in the Context of a University Course: An Exploratory Study. In Proceedings of ITS, June 7-10, 2016, Zagreb, Croatia.

Ginon, B., Johnson, M D., Turker, A., Kickmeier-Rust, M D. (2016). An open learner model used by teachers to monitor speed reading learners. In IWTA workshop of EC-TEL conference, September 16, 2016, Lyon, France.

Ginon, B., Johnson, M. D., Jones, A., Turker, A., & Kickmeier-Rust, M. D. (accepted). Using a persuadable Open Learner Model to support speed reading. To appear in International Journal of Artificial Intelligence in Education.

Ginon, B., Johnson, M. D., Jones, A., Turker, A., & Kickmeier-Rust, M. D. (submitted). Students' Visualisation Preferences When Using A Persuadable Open Learner Model. Submitted to Journal of Learning Analytics.

Göbel, S., Hugo, O., Kickmeier-Rust, M. D., & Egenfeldt-Nielsen, S.(2016). Serious Games—Economic and Legal Issues. In R. Dörner, S. Göbel, W. Effelsberg, and J. Wiemeyer (Eds.), Serious Games: Foundations, Concepts and Practice (pp. 303-318). Berlin: Springer.

Johnson, M.D., Ginon, B., Turker, A., Kickmeier-Rust, M., Bull, S., Masci, D., Khurshid, A., Baber, C. (2016). Using Learnr Model Persuasion with Edidence Data from Other Educational Software: A Case Study. In proceedings of User Modelling, Adaptation and Personalisation (UMAP) 2016.

Kickmeier-Rust, M D., & Albert, D. (2016). Theory-driven Learning Analytics and Open Learner Modelling: The Teacher's Toolbox of Tomorrow? In M. Kravcik, O.C. Santos, J.G. Boticario, M. Bielikova (Eds.), Proceedings of the 6th International Workshop on Personalization Approaches in Learning Environments (PALE), held in conjunction with the 24th ACM International Conference on User Modeling, Adaptation, and Personalization (UMAP 2016), pp. 49-52, July 16th, 2016, vol. 1618, Halifax, Canada.

Kickmeier-Rust, M D., & Albert, D. (2016). Visualizing Competence Models and Individual Learning Paths. In H. R. Arabnia, et al. (Eds.), Proceedings of the 2016 International Conference on Modelling, Simulation, and Visualization (MSV), July 25-28, 2016, Las Vegas, NV. CSREA Press.

Kickmeier-Rust, M D., Bedek, M., & Albert, D. (2016). Theory-based Learning Analytics: Using Formal Concept Analysis (FCA) for Intelligent Student Modelling. In H. R. Arabnia, et al. (Eds.), Proceedings of the 2016 International Conference on Artificial Intelligence (ICAI), July 25-28, 2016, Las Vegas, NV. CSREA Press.

Kickmeier-Rust, M. D. (2015, 11). How Technology can Support Teachers Best. Adjacent Government, Issue 8 Nov 2015, 202-203.

Kickmeier-Rust, M. D., & Albert, D. (2015). Directed Graphs as a Means of Uncovering Learning Processes. In Proceddings of World Conference on e-Learning 2015, October 19-22, 2015, Kona, USA.

Kickmeier-Rust, M. D., & Albert, D. (2015). Lea's Box - Werkzeuge für eine kompetenzorientierte Lernanalyse. In Proceedings of eEducation Sommertagung 2015. Tagungsband: Building Bridges, Creating Networks (pp. 119 - 127). Wien: Österreichischer Bundesverlag Schulbuch.

Kickmeier-Rust, M. D., & Albert, D. (2015). Visualizing the Structure of Learning. In C. D: Kloos et al. (Eds.), Trends in Digital Education: Selected papers from EC-TEL 2015 Workshops CHANGEE, WAPLA, and HybridEd. September 18, 2015, Toledo, Spain.

Kickmeier-Rust, M. D., & Albert, D. (2016). Support Teachers' Predictions of Learning Success by Structural Competence Modelling. In R. Vatrapu, M. D. Kickmeier-Rust, B. Ginon, & S. Bull (Eds.), Proceedings of the Fourth International Workshop on Teaching Analytics, in conjunction with EC-TEL 2016 (pp. 35-39). September 16, 2016, Lyon, France.

Kickmeier-Rust, M. D., & Albert, D. (submitted). A Competence-oriented Learning Analytics Approach for Immersive Virtual Environments. Submitted to eISTA'17 Conference.

Kickmeier-Rust, M. D., & Albert, D. (submitted). Using Structural Domain and Learner Models to Link Multiple Data Sources for Learning Analytics. Submitted to MMLA'17 workshop at LAK'17.

Kickmeier-Rust, M. D., Bedek, M., & Albert, D. (2015). Lea's Box: A Competency-oriented Approach to Facilitate Learning Analytics in School Settings. In T. Kojiri, T. Supnithi, Y. Wang, Y.-T. Wu, H. Ogata, W. Chen, S. C. Kong, and F. Qui (Eds.), Workshop Proceedings of the 2nd ICCE Workshop on Learning Analytics (pp. 372 – 379). November 30 - December 4, 2015, Hangzhou, China.

Kickmeier-Rust, M. D., Steiner, C. M., & Albert, A. (2014). Towards a Hybrid Approach to Learning Analytics, Educational Data Mining, and Personalization for Serious Games. In Proceedings of The joint EC-TEL workshop Learning Analytics for and in Serious Games, September 17, 2014, Graz, Austria.

Kickmeier-Rust, M. D., Steiner, C. M., & Albert, A. (2015). Uncovering Learning Processes Using Competence-based Knowledge Structuring and Hasse Diagrams. In Proceedings of LAK15, Workshop Visual Approaches to Learning Analytics. March 16-20, 2015, Poughkeepsie, NY.

Kickmeier-Rust, M. D., Steiner, C. M., & Albert, D. (2016). Competence-based Learning Analytics as a Means of Personalization in Serious Games. In Proceedings of the Irish Conference on Game-based Learning, September 1-2, 2016, Dublin Ireland.

Kickmeier-Rust, M.D., & Albert, D. (2016). The Learning Performance Vector: Theory-based Learning Analytics to Predict the Individual Learning Horizon. In M. Carmo (Ed.), Proceedings of the International Conference on Education and New Developments (END) 2016, June 12-14, 2016, Ljubljana, Slovenia.

Steiner, C. M., Kickmeier-Rust, M. D., & Albert, A. (2014). Learning Analytics and Educational Data Mining: An Overview of Recent Techniques. In Proceedings of The joint EC-TEL workshop Learning Analytics for and in Serious Games, September 17, 2014, Graz, Austria.

Steiner, C. M., Kickmeier-Rust, M. D., & Albert, A. (2015). Let's Talk Ethics: Privacy and Data Protection Framework for a Learning Analytics Toolbox. In Proceedings of LAK15, Workshop Ethics and Privacy in Learning Analytics. March 16-20, 2015, Poughkeepsie, NY.

Steiner, C. M., Kickmeier-Rust, M. D., & Albert, A. (submitted). Big Data Applied to Education: A Review of Approaches in Learning Analytics and Educational Data Mining. Submitted to Educational Technology & Society.

Steiner, C. M., Kickmeier-Rust, M. D., & Albert, D. (2016). LEA in Private: A Privacy and Data Protection Framework for a Learning Analytics Toolbox. Journal of Learning Analytics, 3(1), 66-90.

Steiner, C. M., Kickmeier-Rust, M. D., Albert, D. (2015). Making Sense of Game-based User Data: Learning Analytics in Applied Games. In Proceedings of the International Conference on e-Learning 2015 (eL).

Wiemeyer, J., Kickmeier-Rust, M. D., & Steiner, C. M. (2016). Performance Assessment in Serious Games. In R. Dörner, S. Göbel, W. Effelsberg, and J. Wiemeyer (Eds.), Serious Games: Foundations, Concepts and Practice (pp. 273-302). Berlin: Springer.

Further Dissemination and Exploitation Activities

Scientific results of the project were disseminated in various conferences, journals and workshops. However, during the third year, evaluation results from the piloting activities that would concern any exploitation strategy were also disseminated to attract not only potential user base, but also potential business partners, third party vendors, and sponsors. *The details are reported in section 2.1.*

The draft plan for exploitation activities that was given in D1.2 second year management Report was turned into a detailed exploitation plan with market analysis, SWOT analysis of the whole system exploitation, competitors due diligence, positioning and concrete actions towards specific business goals. This is the D6.5 Dissemination and Exploitation Plan which was submitted in early September (M30). This plan not only summarizes the exploitation achievements so far but also discloses the consortiums goals and concrete action plan for the final months of the project and beyond.

The exploitation plan has two parts: i) whole system exploitation and ii) exploitation based on distinct business cases. The whole system exploitation is planned to proceed in 4 directions:

1. Background for Other Projects: This direction had the highest potential for immediate exploitation. TUG carries out learning analytics tasks in RAGE and LA4S European projects while SEBIT has similar task in BEACONING H2020 project. In BEACONING, an extended analytics infrastructure developed for the RAGE H2020 project will be used which in turn extends the reference platform developed in the GALA FP7 Project. All these are game-based learning project which is not a target use case for LEA's Box. On the other hand, participation in LAEP and LACE projects led LEA's Box to align with the overall effort in Europe, especially with ET2020 goals and the use of analytics in HEIs. SEBIT has positioned LEA's Box for MoNE FATIH and UNI-FATIH national e-learning platform projects which do lack an analytics layer and SCIO did similar positioning with the Head in the Clouds project. UNI-FATIH is notable in that it aims to align Turkish HEIs with ET2020.
2. Background for a Spin-Off or a Joint Company: The consortium partners made exploitation plans beyond the project life-time and specific actions towards a new joint activity is foreseen in 2017
3. NGO Handover: A number of NGO's are identified in D6.5, but contacts haven't mature yet.
4. Memberships: Below is the status of our work in becoming members in organizations that can present an exploitation channel for the project:

Organization	Partner	Expected Benefit	STATUS
AEA Europe	SCIO	AEA is a leading association for educational assessment researchers and practitioners in Europe. Established in 2000, its principal aim is to foster connections and developments in assessment across Europe and beyond. They have an Annual Conference with over 300 delegates, representing over 25 countries, a LinkedIn site, newsletter, professional accreditation and awards for assessment research. SCIO will be hosting its annual conference in 2017 where there will be a lot of opportunities to engage with potential sponsors in Europe.	Achieved, topics raised during interactions with schools in training and dissemination, piloting "assessment culture" were proposed by SCIO and accepted by AEA as the main topic of the next annual conference…
Trvalá obnova školy13	SCIO	A network of progressive schools in the Czech Republic trying to find efficient methods for running schools. Prospective early adopters and/or promoters. Scio regularly attends their events.	Achieved. Strategically used as major partners; several schools expressed their wish to use LB beyond the project.

Asociace ředitelů gymnázií14	SCIO	The Association of Directors of general high schools of the Czech Republic is a network of headmasters who regularly meet at conferences, organize trainings and events, provide system advice and lobbying. Prospective early adopters or/and promoters. Scio regularly attends their events.	Achieved. Strategically used as main dissemination partners. Schools expressed their wish to use LB after the end of the project. The president of the association took part personally in one of our workshops.
Association of Private Schools	SEBIT	analytics services can be provided through this association to promote a larger business in private schools.	ACHIEVED
CASS	TUG	The CASS Project mission is to facilitate the transition to competency-based education, training, and credentialing through the development and dissemination of open source infrastructure and tools.	ACHIEVED
SOLAR	TUG	The Society for Learning Analytics Research (SoLAR) is an inter-disciplinary network exploring the role and impact of analytics on teaching, learning, training and development.	ACHIEVED
ISTE	TUG	Online Network of educators including journals and the organization of events and conferences.	ACHIEVED
eLSA, Lehrer Online	TUG	The strongest and largest online communities of teachers in Austria and Germany.	ACHIEVED

Specific actions such as releasing evaluation materials, building data adaptors, open sourcing implementations, expositions, and making liaisons with other projects and initiatives that took place during the first of project's final year have been given in D6.5. These actions aim at making the project outcome "market ready." The "go-to market" actions were planned for the last 3 months of the project and beyond (see next table).

ACTION	OBJECTIVE	PARTNER	DURATION	STATUS
Memorandum of Understanding (MoU)	To establish a legal background for commercial exploitation	ALL	August-October 2016	2017

Make the Platform Open Source	To have a reliable, legally clear software basis to exploit	TUG	Sept-Nov 2016	2017
Make Domain Modelling Open Source	To have a reliable, legally clear software basis to exploit	TUG	Sept-Nov 2016	2017
Make Competency State Calculation Open Source	To have a reliable, legally clear software basis to exploit	TUG, UoB	Sept-Nov 2016	In discussion
Make OLM and Visualisations Open Source	To have a reliable, legally clear software basis to exploit	UoB	Sept-Nov 2016	Achieved
Unite OLM and Platform source code under the same open source project	To have a reliable, legally clear software basis to exploit	TUG, UoB	Sept-Nov 2016	Achieved
Result Transfer Workshops	To communicating the exploitation messages and to establish exploitation channels	SCIO, SEBIT, TUG	See the communication plan in the previous table	Achieved
Project Flyer (In 3 languages)	Communicating the exploitation messages	SCIO, SEBIT, TUG	Sept 2016	2017
Final Press Package (In 4 languages)	Communicating the exploitation messages	SCIO, SEBIT, TUG	Sept 2016	2017
External Advisors	Establish exploitation channels via influential advisors	ALL	Sept-Nov 2016	In progress

The second part of the exploitation plan is based on distinct business cases; the details are reported in deliverable D6.5. A summary of the most important activities in these five business cases are as follows:

1. Value-added Feature or Service in a SCIO or SEBIT product: Both partners are leading edtech companies in their respective countries with a number of dominant products. SEBIT products that can make use of LEA's Box tools immediately are HızlıGo, RAUNT and VClass. VClass is being hand over to the MoNE for national use, and further functionalities such as "peer-assessment" is being planned to be added in the years that follow (based on SEBIT's protocol with the MoNE). RAUNT is the leading digital test prep environment in Turkey and data from this product is shared with RTD partners to be evaluated. HızlıGo will soon have a 2.0 release where OLM visualizations are being integrated into which wilsl be the first market implementation of the project as far as SEBIT is concerned. SCIO is bundling peer-assessment tools together with its traditional assessment tools and already had trials in a large number of Czech schools.
2. Value-added Feature or Service in a 3rd party product: Learning analytics software is a burgeoning field with many products in the process of wide-spread adoption, especially in HEIs and adult training market segments. ADL and IMS standardization accelerates this process. The consortium has built contacts and started dialogues with a number of these

players, but this is likely to be a long process, in particular prone to legal issues to settle business interests.

3. Value-added Feature or Service in a National Solution: Both SCIO and SEBIT have strong ties and collaborate with their respective ministries of education. However, projects with ministries must undergo a demanding selection process and must meet a number of legal criteria. Again the contacts and early joint work has been established but this is also likely to be a long process.
4. HEI Academic Assistance: ET2020 goals and action plans, as endorsed by the European Commission demands competency-based educational models which can necessarily benefit from LEA's Box competency-based analytics tools. Such tools are being included in eplatform designs in Turkey within the UNIFATIH project for HEIs (funded by the Ministry of Development). The implementation activities are planned to start in Summer 2017.
5. Content Evaluation Services for Publishers: Most notable action here was the contact with Create 21st in Austria, which is a provider of corporate learning solutions. This is achieved by TUG within project time frame.

Besides these concrete business cases, the consortium made a great effort to establish and endorse "LEA's Box" as a brand, which bears value in itself. Although still under the label of TU Graz and its spin-off Know-Center, this brand will be promoted further after the project is over.

Summary

Summarizing the results of the activities in WP5, we can say that they revealed concrete evidence that a Learning Analytics support of teachers lead to better achievement, engagement and stronger agency. However, these benefits come with 2 conditions.

Technical perfection and fluency at the first contact with the software are the largest determining factors for the users to adopt analytics frameworks for everyday use. Factors such as an easy URL, easy login, simple use cases, browser support, mobile support affects hugely. The evaluation studies also reveal that peer influence is a great factor in adoption. When students start to talk about the application being "cool" or being "cumbersome," the idea spreads very easily and becomes a general belief. Part of the project outcome

The second condition is that the learner, teacher, school, community, society has to be ready to let the analytics influence their learning paths, standards, thinking. As we have seen in some of our countries, the residing habits from the past sometimes obstruct the uptake of learning analytics tools. There is a great need for work to be done on reshaping assessment cultures in our countries.

Take-away message

LEA's Box is a small project, but since "learning analytics" is one of the most popular areas in educational technologies today, the amount of dissemination activities was much more than anticipated, creating larger impact than foreseen. This can be observed not only in the amount and quality of publications, workshop, but also in the wider audience that evaluation activities have reached. With respect to exploitation, the two commercial partners of the project, SEBIT and SCIO, made use of their dominance in their respective countries and their ties with the ministries to spread the pilots and create compelling value propositions. The modular approach of LEA's Box made it easier to craft the exploitation business cases. Accordingly, the first market implementations have started during project lifetime. However, neither company is much active at European scale, in terms of operations in other EU countries. On that front, TUG had been active as TUG is a key partner in a large amount of EU projects. Finally, in terms of ROI, the consortium aim is first to get wide-spread adoption by adding value to established products. The full commercialization should follow once the adoption gap is bridged, which also have dependencies to the resolution of legal matters related to intellectual property rights within the Consortium.

1.4 Summary of Achievements and Advancements of the State-of-the-Art

The following lists the concrete objectives and describes the solutions developed and published by the project.

It is critical to develop a Web platform that has connections to existing components and interfaces to a broad range of educational data sources. This way, teachers can link the various tools and methods that they are already using in their daily practice and bring them together in one central platform.

Lea's Box offers a central web platform (portal) that allows teachers and students to access the features and functionalities of Lea's Box. Key achievements include a broad data model for gather and analysing large multi-source data sets as well as 2 APIs, the internal Lea's API and the TinCan/xAPI functions. In the use cases we presented, we demonstrated that the Lea's Box system can be used with internal as well as external tools (e.g., the Speed Reading App or SCIO's SCATE test system).

It is important to provide a set of easy to use tools and Web services to have an initial set of functions for ready for the use by teachers. These components should support activity tracking, domain modelling, or visualization of educational data. The components primarily originate from the consortium's portfolio of existing developments, tools, and products.

In the context of the project, we integrated (and sign. advanced) the myClass system from the Next - Tell Project, the Rule Engine (to reason over general performance data) from the Next-Tell Project as well as the FCA-Tool from WeSpot. In addition n we integrated the CbKST -based "micro-adaptivity" engine to perform basic CbKST analysis (as the basis for the new Hasse diagram visualisation n module). In addition, SCIO made it *SCAT*E test system available and SEBIT this *Hizligo* Speed Reading Training.

In the main focus of the project is to plan, design, develop, and host innovative LA/EDM services, empowering educators to conduct competence-based analysis of rich data sets. The project pursues an approach of featuring modular components to filter, streamline, and aggregate data from various sources, to analyse and interpret these data, and to store them safely. Special considerations address data protection and privacy requirements. The set of modules, services and data streams must be controlled by a superordinate component, the central executive. This approach will provide a strong system operating in the background while hiding complex functionalities from users.

As reported in the deliverables of the project, specifically those of WPs 2, 3, and 4, all relevant features and additional ones, based on our user studies and experiences, have been implemented. The following figure illustrates the implemented components. The core feature is the so-called

Central Executive. This component controls the data flow and triggers the analyses. In addition, it is responsible for storing the data and for engaging the data analysis warehouse. The latter is a separate and new feature that has been developed to increase the computational speed of various analyses, specifically those of longitudinal, time-based data.

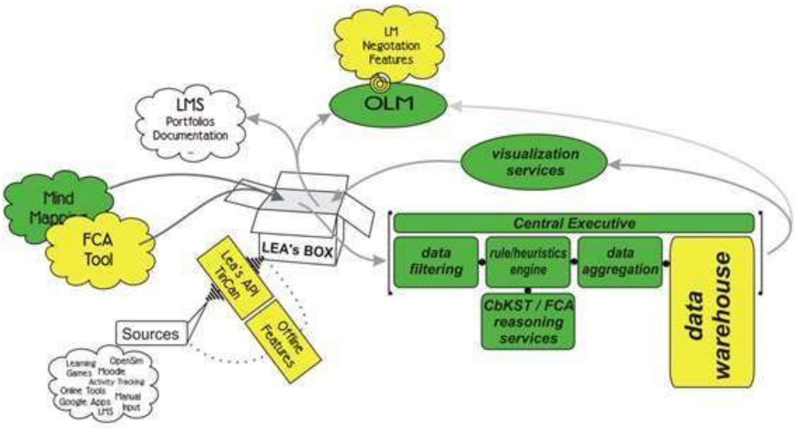

Figure 17. Revised and extended system architecture.

Lea's Box focuses on the one hand on the theory-driven approaches of CbKST and FCA, on the other hand, a strong focus lies on Open Learner Modelling (OLM). Both strands provide visualization and feedback methods for users. Lea's Box is dedicated to develop and deploy such innovative visualization services.

In the course of the project we fully integrated and advanced the OLM system, in addition we developed new FCA type lattice visualizations and a powerful and computationally fast Hasse diagram visualization module. We simplified the Hasse diagram module and we enriched the Hasse diagram module with colour coding and an adaptive selection of individual learning paths. Several visualisations have been added to the OLM, notably two multi-dimensional visualisations: the across time visualisation and the heat -map visualisation. Using the across time visualisation it is possible to see the evolution of the model since its creation. Using the heat-map visualisation, it is possible to see the links between two dimension n of the model (the competencies, the groups, the students, the activities and the information sources). For instance, it is possible to see how much each activity has contributed to each competency.

An important aim of Lea's Box is to support a direct feedback to students. The OLM is dedicated to this aim. A distinct envisaged extension is a negotiation feature.

The OLM's key strength is that it opens analytics processes not only to teachers but also to students. Students can enter the system, retrieve feedback and information about their own performance, and gain an understanding about the reasons for certain analytics outcomes. This is pedagogically important but also relevant from an ethical perspective by fulfilling the requirement for transparency. In Lea's Box we wanted to go a step further and allow students to intervene and negotiate the outcomes of analytics. In the course of the project we developed and deployed such feature for the OLM and evaluated it in studies with university students.

In the very nature of the project is the interoperability with a range of other tools. This includes the provision of interfaces and links to export/report data and to transfer them to external tools. Also, a critical aspect is to provide users with features to configure the system. In a complex setting – such as multi-source multi-faceted learning analytics – the necessary configuration work is not trivial and requires a certain amount of efforts.

We designed and developed a fully functioning configuration tool that allows undertaking all relevant tasks (e.g., defining competencies, adding students and classes, etc.). This tool includes bulk-upload functions for csv formats to facilitate the import of existing data sets (e.g., competencies, students, etc.). Through this configuration tool we have also implemented function for an easy in- and export of data in different formats. A special highlight is the development of a performant, web-based CbKST functionality to establish prerequisite relations among competencies and the derived the related competence spaces. This is a very important innovation not only in the Lea's Box context but for the entire user modelling community.

Dissemination and training activities are critical to enable the project to generate impact.

As reported in previous sections of this document, the project spend significant efforts and realized a highly successful dissemination strategy. Through the blog and website we tried to approach all groups of stake holders and published semi-scientific articles about learning analytics (learning analytics for guitar players, learning analytics for chefs, learning analytics for painters). As major training event we organized – only as one example – the "Bildung 4.0" ['education 4.0'] seminar or the "Freiräume" ['open spaces'] networking event in Austria.

Figure 18. Professional graphics for Lea's Box dissemination activities.

Technical Performance Indicators

As of the original plan of the project, the final, overall success indicators are available and tested components and concrete functions for

- **an evidence-based generating /validating the teachers' domain models and teaching plans**
  > The solutions are available through the mind mapping tool the FCA tool, the CbKST functionalities, and – not least - the configuration tool

- **the identification of individual learning paths and individual learning progress**
  > CbKST analyses (illustrate by Hasse diagram visualizations) provide teachers with insight into learning processes and pathways. The OLM allows user-centred communications of the analytics results and allows identifying the activities and evidences that lead to the results.

- **the prediction of individual learning trajectories**
  > Research into the Learning Performance Vector as means of predicting learning success over time has been completed and the technical realization has been implemented. In simulative studies we elucidated the strength and limitations of the performance prediction approach.

- **the adaptive assessment of competencies and competence states**
  > This is technically realized with the CbKST analysis engine of the central executive. Adaptive assessment, however, can only occur in an interaction with an external assessment tool. The features (API) for the data exchange are technically available.

- **the identification of individual learning styles**
  > Technically the foundations for a FCA-based identification of clusters in big data sets are available. The approach has been investigated in the context of user studies in year 3 in Austria (cf. deliverable D5.6). The main conclusion of the revised report on Learning Styles (deliverable D3.5) is that the concept suffers from various weaknesses and a lack of clear empirical evidence. Thus, we did not pursue a more in-depth technical implementation. However, the result influence the revision and update of a teacher handbook for treating individual learning styles and modes, which is a product of SCIO.

- **the evaluation of the effectiveness of teaching methods and materials**
  > The OLM provides teachers with such information on a comprehensive basis. The OLM the FCA tool allow an inquiry-based approach to teaching and learning.

- **the visualization of data and the results of analyses**
  > As reported in the context of WP4, the project delivered a set of (partly highly innovative) visualization services and methods, specifically through the Olm system.

- **the appropriate communication and reporting of teaching/learning activities**
  > The OLM pro ides teachers with such information, in addition, myClass has several reporting features (including the automatic generation of report cards).

- **the appropriate communication and negotiation of individual learning achievements**
  > This is provided by all reporting and visualization features of the 'box', particularly the OLM system. For the OLM we developed and evaluated the negotiation module

The performance metrics are based on the following dimensions (p.30 of Part B of the project contract):

- functionality and adequacy of developed components
- stability and computational speed
- feasibility and potential limitations of an application in
- usability and comprehensibility of the user interfaces and particularly the data visualization components
- effectiveness, reliability, and validity of LA/EDM algorithms
- identification of logistical and practical obstacles in the application of such system
- acceptance of such technology

In the context of WP5 we have developed an evaluation framework that maps system components and these performance metrics. In the context of WP5, moreover, we covered a large number of those aspects with different evaluation and user studies. We can conclude that the prototype system meets these requirements to a satisfying level. As WP5 revealed, particular strengths are seen in aspects such as functionality and the overlap with the pedagogical questions (which we made the basis for conceptual developments) as well as feasibility and the alignment to practical needs and obstacles. Particular weaknesses of the prototype are certainly related to usability and also comprehensibility. Usability and acceptance indicators are extremely diverse across Europe, even across individual countries, and school types. This makes it very difficult to meet al demands and expectations but we believe that Lea's Box clearly contributed to solutions and approaches that may find a wide uptake.

How did the project advance the state of the art?

The project pursues 2 major work strands; first a basic research strand, focusing on theoretical research in order to link, perhaps even unify, the theories of FCA and CBKST. Second an application oriented strand that aims at providing teacher with concrete and usable tools with a focus on every day school practise.

State of the art in theory-driven Learning Analytics

The project successfully introduced the well-elaborated theoretical approaches in the field of intelligent tutorial systems as means of supporting Learning Analytics beyond mere statistical analytics. This bears the big advantage that learning analytics as well as data mining are enriched with domain and user models, which allows a strong focus on competencies and which allows making very concrete recommendations (e.g., about which competencies should be attended by an individual student to maximize learning progress). This is novel in the field. Specifically the combinatoric, structural competence modelling is a novel and important factor to bring together various sources and base analytics upon those multiple data. This is particularly true when we are talking about sources with different types of data, different qualities of data, with different temporal aspects, as well as with different importance for the global analytics. This is novel in the field. In addition, some ground-breaking mathematical, conceptual work has been accomplished, advancing the general state of the art, particularly in FCA. This work has been completed in a 3-day expert workshop hosted in Graz. Prof. Jürgen Heller (Tübingen), Prof. Bernhard Ganter (Dresden), Prof. Reinhard Suck (Berlin) and Dr. Cynthia Glodeanu (Dresden) discussed with the Lea's Box team how CbKST and FCA can fertilize each other to establish a solid theoretical basis for Learning Analytics. Although the results did not influence the learning analytics solution of Lea's Box yet, we could accomplish a significant step forward. The results are to be published in a joint article.

Figure 19. Lea's Box presented at SBIM 2016 by pre-service teachers of our partner school "Grazer Schulschwestern"

Finally, we introduced the conceptual-theoretical approach of the Learning Performance Vector and the Learning Horizon. This is a method, based on traditional CbKST, which allows making predictions about possible learning success on the basis of the existing learning path of an individual, the remaining number and complexity of competence development steps towards a well-defined learning goal and on the basis of the remaining time for reach the goal (e.g., the end of a semester). This is an entirely novel approach. In a simulation study we elaborated on the characteristics, strengths, and weaknesses of the approach in comparison to a linear statistical approach (as reported in deliverable D5.8).

State of the art in the computational performance of structural, competence-centred analytics

Figure 20. Lea's Box teacher training event in Austria.

Past experiences with CbKST and FCA showed that, particular in settings with large competency models and man students, real-time analyses were a problem. In addition, we learned that the demands of educational settings are extremely diverse across countries, school types, teachers, pedagogical principles so that a comprehensive data model is difficult to define. This is specifically true when also adding the requirements of the multi -source approach where internal and external data sources, the related competencies, weights, activities, etc. must be defined. Besides the fact that such "global" model is difficult to define, the resulting complex data structure in turn makes real-time analyses slower. Lea's Box clearly advanced the state of the art by proposing a data model that is more complete than those we had before and that is more capable of covering all the various demands. To assure satisfying computational speed we developed and implemented the FLASH "data analyses warehouse" that can perform statistical as well as structural analyses with a satisfying computational speed.

Competence-based Knowledge Space Theory and Formal Concept Analysis

Competence-based Knowledge Space Theory (CbKST) and the Formal Concept Analysis (FCA) originate from different research fields. The CbKST comes from the field of intelligent tutoring systems and learner modelling; the FCA comes from the field of applied mathematics, aiming to describe knowledge domains by means of concept hierarchies. However, they share some structural features and a similar set - and order theoretic language. In the case of the FCA, LEAs BOX attempts to apply the theory for learner modelling, i.e. for describing learners' current competence - or performance states and how to reach a particular target state.

Figure 21. Marieke of Lea's sister project WatchMe presents her project at Lea's EC-TEL workshop in September 2016.

From a conceptual perspective, work has been carried out to further investigate the similarities and differences from a set-theoretic and order-theoretic point of view (i.e. structural properties, such as closeness under union etc.). As an additional outcome of this comparison between these two theories, the FCA has been applied for learner modelling as attempted, by considering students and competences or performance data in the formal context. This approach of learner modelling is purely "data-driven", i.e. the FCAs´ structures (lattices) directly results from the students' performance data, compared to the CbKST which is more "theory-driven" since domain experts (e.g. teachers) define the relations between the competences beforehand. For a more-depth analysis of the comparison, we also included different algorithms of the Inductive Item Tree Analysis (IITA), another "data-driven" approach to identify the relations between performance data such as outcomes on tasks or test-items (explorative data analysis). Another conceptual research stream focused on the identification of pedagogical questions (such as: What are the next suitable learning steps for a particular student?) which can be either answered by one of the theories or by both of them. Finally, work has been carried out to simplify the resulting visualizations based on the two theories, i.e. either concept lattices or competence spaces, and how to make them more intuitive without the loss of information. As an example, for showing different suitable learning paths through the knowledge domain, LEAs BOX utilizes interactive structural Hasse-diagrams.

From the technical development side, the so-called FCA tool has been incorporated to the LEAs BOX platform. This tool has been initially developed in the course of the EC-funded weSPOT project. In the context of LEAs Box, the tool has been polished and adapted to the needs of our project. For the CbKST and similar approaches, the "Learning Spaces" tool has been further developed and incorporated in the web platform. This tool is for visualizing and interacting with the structural Hasse diagrams.

State of the art in open learner modelling and interactively maintained models

LEA's Box provides a stable and functional open learner modelling system (OLM). The system has been fully connected to the web platform which serves data acquisition. The OLM has been equipped with new visualisation features base d on the user studies of the project. The OLM provides learners with a persuasion facility that enable learners to view the system evidence for their level in every competencies and to try to persuade the system to amend their model if they disagree with it by providing justification(s) or challenging evidence. The most common moves found in the related works are available in this persuasion facility (agree/accept, disagree/decline, request/provide evidence/justification, self-assess, offer compromise, statement). Even though the persuasion facility is classical, Lea's Box advanced the state of the art by providing a persuasion facility for a domain- independent OLM, with multiple external data sources, without a need have knowledge on these data sources.

Figure 22. Scene of Lea's Box promo video.

Technical Stat of the Art

Figure 23. Lea's Box tries to bring her experiences and expertise also to standardization bodies such as the Austrian Standardization Institute and even ISO in the PC288 on ISO/PC 288 Educational organizations management systems!

In the context of the technical development, the project advanced the state of the art (i.e., the existing tools and apps in this particular field) substantially. We advanced the components for performing competence-oriented structural analytics and we tightly integrated the originally loosely linked components. This refers to the analytics components, the reasoning components, the components to control the data flow, and the data analysis warehouse. In addition, we developed a comprehensive configuration tool that fully integrates the analytics system with the OLM. At this level this is novel and the work towards the integration has not been trivial. The technical advancements also refer to the set of newly developed visualization modules. For example, we could enrich the OLM with temporal visualizations, which is novel. Another example is the extension of the concept of Hasse diagrams in order to integrate more information in the original simple directed graph (e.g., difficulty or grouping information, colour coding of probability, highlighting and selecting individual learning paths).

State of the Art of Learning Analytics in Education

Figure 23. Lea's Box even makes it to Hollywood!

Lea's Box makes it possible for teachers, in the daily professional life that is normally a rather technology and data lean one, to generate data very easily and without requiring the setup of complex tools and also to link those data that are already available but that are completely disconnected and often unused. This is a key foundation of making teachers use data for improving their teaching. More importantly, Lea's Box shows teachers ways to make the conceptual change from performance oriented assessment and teaching to a competence oriented assessment and teaching. Here we meet an important recent trend all across Europe. By the modular and simple approach and design of the 'box' we can meet teachers where they are. Thus we provide them with tools 'underneath' Learning Analytics, which however correspond to their mental models, expectations, and needs. Examples are the Mind mapping tool, or the 'trivial' feature of generating report cards automatically. The entire box, even if it is still a prototype, brings the fundamental ideas of Learning Analytics ('data' and the usage of data) closer to the classrooms than ever before.

DELIVERABLES YEAR 1								
No.	**Deliverable name**	**Version**	**WP no.**	**Lead beneficiary**	***Nature***	**Diss. level1**	**Delivery date from Annex I**	**Status**
D1.1	Periodic Report	1	1	TUGraz	Document	PP	M12	Submitted
D2.1	System Design Document I	1	2	TUGraz	Document	PP	M8	Submitted
D2.3	Privacy and Data Protection Policy	1	2	TUGraz	Document	RE	M10	Submitted
D2.4	System release I	1	2	TUGraz	Software	PU	M12	Submitted
D3.1	Review article about LA and EDM approaches	1	3	TUGraz	Document	PU	M8	Submitted
D3.2	First release of LA/EDM algorithms and services	1	3	TUGraz	Software	PU	M12	Submitted
D4.2	First release of visualization and OLM services and tools	1	4	UoB	Software	PU	M12	Submitted
D4.6	Research report on interactive OLM negotiation techniques	1	4	UoB	Document	PU	M12	Submitted
D5.1	Piloting and evaluation plan	1	5	Scio	Document	RE	M8	Submitted

D5.2	Focus groups and design report	1	5	Scio	Document	PU	M6	Submitted
D6.1	Project website launch	1	6	Sebit	Other	PU	M3	Submitted

DELIVERABLES YEAR 2								
No.	**Deliverable name**	**Version**	**WP no.**	**Lead beneficiary**	***Nature***	**Diss. level1**	**Delivery date from Annex I**	**Status**
D2.2	System Desi gn Document II	2	WP2	TUGraz	Document	RE	M18	Submitted
D3.5	Review article about learning styles and cognitive styles	1	WP3	TUGraz	Document	PU	M14	Submitted
D3.3	Second release of LA/EDM services and algorithms	2	WP3	TUGraz	Software	PU	M22	Submitted
D4.1	Review article about educational data visualization	1	WP4	UoB	Document	PU	M18	Submitted
D4.3	Second release of visualization and OLM web services and tools	2	WP4	UoB	Software	PU	M22	Submitted
D5.3	Revised focus groups and design report	2	WP5	Scio	Document	PU	M16	Submitted

D5.4	Piloting and evaluation report I	1	WP5	Scio	Document	PU	M14	Submitted
D5.7	Report of Dissemination and Training Activities		WP5	SCIO	Document	RE	M24	Not Submitted

DELIVERABLES YEAR 3								
No.	**Deliverable name**	**Version**	**WP no.**	**Lead beneficiary**	***Nature***	**Diss. level1**	**Delivery date from Annex I**	**Status**
D1.3	Final Report	2	WP2	TUGraz	Document	RE	M34	(Draft) Submitted
D2.6	System Release III	1	WP2	TUGraz	Software	PU	M31	Submitted
D3.4	Final release of LA/EDM services and algorithms	1	WP3	TUGraz	Software	PU	M31	Submitted
D4.5	Final release of visualization and OLM web services and tools	1	WP4	UoB	Software	PU	M31	Submitted
D5.6	Piloting and evaluation report III	4	WP5	SCIO	Document	PU	M34	Submitted
D5.8	Training and dissemination workshop report II (including the contents of the not submitted deliverable D5.7)	2	WP5	SCIO	Document	PU	M34	Submitted

D6.2	Website Finalization	1	WP6	SEBIT	Other	PU	M34	Submitted
D6.5	Dissemination and Exploitation Plan	2	WP6	SEBIT	Document	RE	M30	Submitted
D3.5	Re-submission of the rejected deliverable D3.5 “Review article about learning styles and cognitive styles”	2	WP3	TUGraz	Document	PU	M28	Submitted

[1] **PU** = Public

PP = Restricted to other programme participants (including the Commission Services).

RE = Restricted to a group specified by the consortium (including the Commission Services).

CO = Confidential, only for members of the consortium (including the Commission Services).

EU restricted = Classified with the mention of the classification level restricted "EU Restricted"

EU confidential = Classified with the mention of the classification level confidential " EU Confidential "

EU secret = Classified with the mention of the classification level secret "EU Secret "

Milestones							
Milestone no.	**Milestone name**	**Work package no**	**Lead beneficiary**	**Delivery date from Annex I**	**Achieved Yes/No**	**Actual / Forecast**	**Comments**
MS1	**Kick-off Meeting**	**WP1**	**TUGraz**	**M1**	**YES**	**-**	**-**
Ms2	**Launch of website**	**WP6**	**SEBIT**	**M3**	**YES**	**-**	**-**
MS3	**System Release I**	**WP2, WP3, WP4**	**TUGraz**	**M12**	**YES**	**-**	**-**
MS4	**System Release II**	**WP2, WP3, WP4**	**TUGraz**	**M24**	**YES**	**-**	**-**
MS5	**System Release III**	**WP2, WP3, WP4**	**TUGraz**	**M31**	**YES**	**-**	**-**