

Intelligent Learning Extended Organizations

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Abstract

Intelligent Learning Extended Organization (IntelLEO) is a new paradigm in learning communities. It represents a community that emerges as a temporal integration of two or more different business and educational communities and organizational cultures (industrial, research, and educational). The concept of IntelLEO is going to be investigated in a 3-year R&D project accepted for funding within the EU Seventh Framework Programme (FP7) and starting in early 2009. The project involves 8 partner institutions from Europe (both university/research and industry) and one from Canada. This paper presents the innovative concept of IntelLEO from the business case, technical, and pedagogical perspectives.

Introduction

The term *Intelligent Learning Extended Organization (IntelLEO)* denotes a learning community emerging as a temporal integration of two or more different business and educational communities and organizational cultures. The integration happens on the grounds of common interests of the organizations/institutions involved, in terms of knowledge transfer and harmonization of interests and objectives of the organizations/institutions and their members. For example, there may be one or two companies from industry, a university, and a training institution. They may want to collaborate and share business and educational efforts through performing various vertical and horizontal *learning and knowledge-building (LKB)* activities. Vertical LKB activities are performed within the organizations involved, whereas horizontal LKB activities can be performed within and between the organizations (Tuomi-Gröhn and Engeström, 2003).

In a learning organization based on this idea – we call it an IntelLEO organization, or just IntelLEO – learning and harmonization of individual and organizational objectives happen at different temporal collaborative knowledge-building and learning groups. In other words, the IntelLEO emerges across various boundaries, by vertical and horizontal activities of various individuals and groups involved.

The *responsiveness* of an IntelLEO is the observable performance in which individuals are motivated to proactively learn and construct knowledge. This responsiveness can be increased if:

- individuals are technologically supported to participate in collaborative LKB activities across vertical and horizontal boundaries of the IntelLEO; and
- their personal objectives of learning and creativity are dynamically harmonized with the organizational LKB objectives of different IntelLEO counterparts.

In order to support individual, collaborative, and organizational LKB activities, IntelLEO assumes a service-oriented approach/architecture (SOA) based on two kinds of services (Figure 1):

- services for efficient management of collaborative LKB activities and access to and supply of shared content (called *LKB services*); and
- services for harmonization of individual and organizational objectives (called *harmonization services*).

A distinguished assumption in the IntelLEO framework is that the effectiveness of the technological support for the learners and the responsiveness of an IntelLEO is achieved by the *synergy* of the two kinds of services. The increase of responsiveness is defined through the learners' increased motivation to proactively learn and construct knowledge in an IntelLEO.

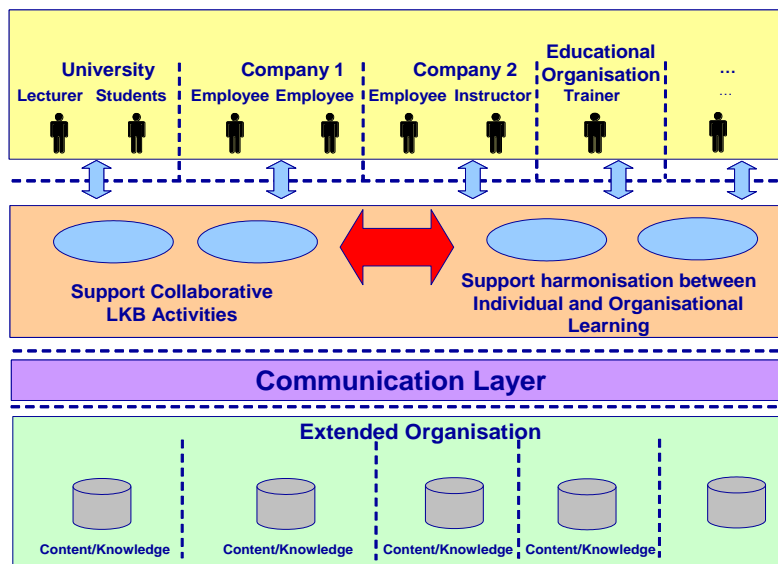


Figure 1 – The conceptual framework of IntelLEO

The IntelLEO paradigm has been recently conceptualized and will be investigated in detail within the recently approved, forthcoming EU Seventh Framework Programme (FP7) project starting in early 2009. The project acronym is also IntelLEO. The main objective of the IntelLEO project is to explore how the responsiveness of the LKB environments in an IntelLEO organization can be enhanced by advanced technology exploiting, in an innovative way, the synergy between LKB and harmonization services. The project intends to design, implement, and evaluate technical solutions to optimally exploit this synergy in an IntelLEO organization.

Business Cases

To explore the synergy between LKB and harmonization services, the IntelLEO project will address both industrial and educational organizations where the motivation of learners, collaborative LKB, and harmonization between individual and organization learning objectives are the most critical. To this end, the project team has formulated three business cases (BC) that will be supported by the technology to be developed during the course of the project. Simultaneously, the three BCs will serve as a baseline of the project development and will be used to validate the assumption related to the synergy between LKB and harmonization services.

Each BC involves a different configuration of business and educational institutions, all involving knowledge transfer and harmonization of objectives between different organizations.

Business Case 1

(IntelLEO configuration: a large industrial enterprise and a university/R&D institution)

Volkswagen AG (VW), Germany, is a large industrial partner in the project. They will form an IntelLEO with *Institut fuer angewandte Systemtechnik Bremen GmbH (ATB)*, Germany, is a leading R&D institution from Bremen, Germany, associated with the University of Bremen. VW wants to use the IntelLEO project services to share its contents (in the form of various learning objects (LOs) and other knowledge resources related to tolerance analysis and their new CAD system) among its subsidiaries and suppliers and the University of Bremen/ATB. For example, when trained on tolerance problems, learners may get knowledge on actual problems in VW regarding tolerances. This opens a possibility for the learners to contribute to solving these problems by providing their knowledge. Likewise, when encountering a certain tolerance-related problem an employee may identify the learning content appropriate for his training and identify an appropriate learning group. It will be also investigated how new services may be used to optimally combine different learning material and offer the best choice for each individual in both organisations (both design and manufacturing engineers, students at university, researchers, etc.).

Business Case 2

(IntelLEO configuration: an international business network and a university)

Another industrial partner in the project, INI, is an SME from Belgrade, Serbia, and is a part of a large world-wide business network. INI is delivering innovative Web-based solutions for emerging global e-Engineering and e-Manufacturing. One of their best known products is Key to Metals, the leading set of databases on metals in the world. INI is interested in exploring the possibility to implement an IntelLEO with the Faculty of Organizational Sciences (FOS), University of Belgrade, Serbia, and possibly extending it further to other partners in the business network and other universities. On the other hand, experts from FOS are interested in having access to real-world knowledge collected from metal working industry within the network to which INI belongs. One of the topics for such strategic collaboration between INI and FOS in the e-Engineering and e-Manufacturing areas is customer relation management (CRM). Surveys conducted so far show that many of INI's customers worldwide want to extend their business with INI, but often need to learn more about the options they have and related cases that other customers had so far. In order to better understand the customers' needs, INI wants with FOS to deploy TEL to augment their CRM system. It is FOS' research interest to help INI develop LKB and harmonization services for the CRM system. In return, FOS will be granted a partially open access to INI's servers' log files and further customer surveys, representing real-world data and knowledge about customers' interaction with the learning services implemented. It will enable FOS to monitor the customers' interaction with the services, perform analysis, and improve the services further.

Business Case 3

(IntelLEO configuration: schools and a university)

Estonian Association of Professional Teachers (EAPT) and the Centre of Educational Technology of Tallinn University, Estonia, are the project partners who want to explore the IntelLEO paradigm in improving professional teachers' work practice and their life-long learning and accreditation mechanisms at schools, as well as in supporting the teachers' career-related activities and vocational training. EAPT is currently actively involved in teacher education at universities and workplaces (schools), through implementation of technical structures that scaffold cross-institutional transfer of knowledge and support individuals in harmonizing their personal objectives with those of the universities and workplaces. Integrating academic (mostly explicit) knowledge of university staff and practical (mostly tacit) knowledge of teachers is one of the main challenges in the field of teacher education. So far, boundary-crossing knowledge-building activities between schools as teachers' workplaces and teacher training institutions have been occasional and with low impact. In collaboration with Tallinn University, EAPT wants to test the IntelLEO paradigm and services in increasing the motivation of teachers to proactively participate in lifelong learning and harmonizing their personal learning objectives with those of their schools.

Approach and Services

It is envisioned that much of LKB in an IntelLEO will naturally come through collaborative learning activities. Thus the project will develop a repository of *collaboration models (CMs)* to store information that characterizes collaborative (learning) situations. It will formally be described as an ontology with

concepts and relations directly derived from the collaborative situations (e.g., person, organization, collaboration situation (learning topic), collaboration pattern, time, location, synchronicity (asynchronous, synchronous, multi-synchronous), etc). These concepts and relations can also be seen as “semantic labels” for the instances stored in the repositories of learning resources. CMs will be built based on *collaboration pattern models* relevant for collaborative learning (e.g. asynchronous/synchronous learning, location, time, etc.). The approach of *Information Pyramid* of virtual collaboration with different levels of information granularity (Biuk-Aghai, 2003) will be used. The project will specifically study and identify the collaboration pattern models that characterize collaborative LKB in IntelLEO.

To support collaborative LKB activities in an IntelLEO, LKB services must be highly flexible, scalable, and easy to integrate in different ICT environments of different actors within an IntelLEO. The IntelLEO project intends to provide a number of such services and enable using them in combination with existing Portfolio Software Solutions (PSS) and Learning (Content) Management Systems (L(C)MS). This way, the impact of the services on new ways of collaboration between industry and educational institutions can increase. Table 1 outlines several categories of these services.

Table 1 – Collaborative LKB services

Service type	Input/request	Output	Main functionality	Specific requirements
(Human) Resource Discovery	Request for specific expertise, trainers, partners	Appropriate and available expert(s), trainers, partners for LKB Pro-active resources provision (without request)	Searching for expertise to support LKB in an IntelLEO, trainers and partners, according to the defined objectives Checking availability	Mobile users, Already defined groups, Different discovery approaches (see the text to follow) Link to human management systems in an IntelLEO
Learning Group Composition	Request for an optimal learning group	Optimal group (structure, members etc.)	Proposes group based on identified available expertise, trainers and partners, individual learning paths and IntelLEO objectives	IntelLEO rules etc.
Collaboration Traceability	Request for tracing of the group LKB	Info on the learning process and the current state of groups and collaboration, Info to react on certain events	Tracing of LKB collaboration: - continuous - event driven (event identification) Tracing of: Team results Content/course usage, Learning styles, Interaction (type, frequency etc.) Feedback services - user may enrich learning resources. Mechanisms for context capturing	Specific requirements regarding security, IntelLEO specific rules, IPR, privacy Allowing different levels of details (abstraction)
Learning Resources Provision/Discovery	Request for learning resources on specific issue in the given context	Learning resources relevant for specific issue (e.g. manufacturing problem) and context	Discovery/delivery of learning resources within an IntelLEO using context defined; Proactive provision of resources; Provision of knowledge on learners/groups	Documents, Stored user knowledge, Distributed databases with data from processes or products in the network, Dynamic delivery, Support for different learning styles Pro-activeness – suggesting further readings according to the (automatically updated) learner/group model.

Two types of harmonization services will be developed during the course of the project, Table 2. *Learning path generation/planning services* will support the fact that learners with different backgrounds and belonging to different learning groups will not only need different learning resources, but will typically use different paths/sequences in consulting the resources. Learning path generation services will define needs/criteria for providing resources for a specific user/group, and learning resources discovery services will then discover the resources that best fit the needs. The learning path for a specific user can be built starting from an analysis of her/his cognitive and affective needs and objectives set for different contexts. In addition, the ways the user planned to realize those objectives and the criteria defined to evaluate how well did she/he achieved her/his objectives, and the needs of the organisation (defined via organisation policy services) should be taken into account as well. All this can be acquired from the user’s e-PSS.

Organization policy services support learning processes of individuals inside an organization by providing organization objectives and policy within the LKB activities in an IntelLEO. These services represent a type of bidirectional filtering functions for the learning contents and collaborative LKB, with respect to the organization's specific learning objectives and policy. They may filter the resources that may be combined

in order to fit to the organizational policy. On the other hand, organization policy services select the most appropriate learning resources for the individuals of the IntelLEO (out of those provided by the learning path generation and learning resources discovery/provision services). They also support selection (filtering) of human resources for collaborative learning. To implement organization policy services, new methods and tools for the filtering process will be developed using semantic reasoning approaches to dynamically incorporate the needs and objectives of organizations in the learning process of individuals.

Table 2 – Harmonization services

Service type	Input/request	Output	Main functionality	Specific requirements
Learning path generation (planning)	Request for learning path for an individual/group to achieve stated objective(s)	Proposed path for individual/group consistent with the stated objective(s) (e.g. gradual increase w.r.t. the cognitive capabilities)	Selection of the learning sequence and most appropriate criteria to provide resources in a specific context (for specific learner and/or group etc.) Provision of knowledge on learners/groups	Link to human management systems in IntelLEO. Knowledge on learner/group Works in combination with Learning resources provision/discovery services (see the text above).
Organization policy	Request for organisation rules, objectives. Request to filter content	Provision of organisation rules, and/or objectives relevant for specific content/context Selected content/context according to the organisation policy	Identification of rules and/or objectives, which are relevant for the specific content/context Filtering from the set of provided content/knowledge those which fit with the rules, objectives, strategies	Services interconnected with the organisation legacy system containing information on companies rules, dynamic updates of rules, objectives

The real power of the IntelLEO framework comes through *interrelation of services* presented above. These services may "profit" from each other, thus leading to a higher responsiveness of the learning environment in an IntelLEO. The project will establish and explore several interrelations among the proposed services, such as:

- Services for collaboration traceability will provide information on the *context* of learning/collaboration. This information can be used by services for learning path creation to assure the content/knowledge that best suits the individual and/or group, as well as by organization policy services to provide appropriate rules/objectives.
- A learning path selected by learning path generation services will provide information for future human resource discovery and learning group composition. This can accommodate different collaboration patterns and different technical backgrounds of the collaborating people.
- Traceability services will provide information about collaboration patterns applied by different learning groups. It may reflect upon organizational policy services.
- Learning resources provision/discovery services will proactively support the learners, and will also trigger human resources discovery services to suggest the learners topics to discuss with some other learner(s).
- Organization policy services will provide rules for human resource discovery and learning group composition services.
- E-portfolios and collaborative LKB services make a good combination when a learner can do something individually. They can keep track of the learner's activities and (possibly changing) objectives.

Technical Aspects

The IntelLEO paradigm relies on intelligent technologies to support LKB activities. For example, the binding element for the interrelation of services will be the *LOCO framework* (Jovanović et al., 2007). LOCO stands for Learning Object Context Ontologies and integrates a number of ontologies related to learning resources and practices (such as learning object content structure ontology, learning design ontology, learner model ontology, collaboration model ontology, learning context ontology, and various domain ontologies). The ontologies will be used to represent the knowledge about the components of the

IntelLEO framework, its actors (learners and organizations), services, CMs, and learning contexts. In the LOCO framework, learning context is understood as a specific learning situation, determined by the learning activity, the learning content, and the (group of) learner(s) involved.

The services and their interrelation will be developed to fit the *Collaborative Reference Architecture (CRA)*, Figure 2, relevant for the industrial, university and other working environments. The objective is to allow for an effective combination of these new services with the existing or emerging services for collaborative work, which in turn will allow better integration of LKB activities with the everyday work. Note in Figure 2 that all core services from Tables 1 and 2 are supposed to be orchestrated in various ways to achieve the synergy needed in various LKB applications, i.e. IntelLEOs (such as those discussed in the section on the business cases to be supported by the project). This way, services are combined to, e.g., provide the learner with a custom "view" of the repository of learning resources available.

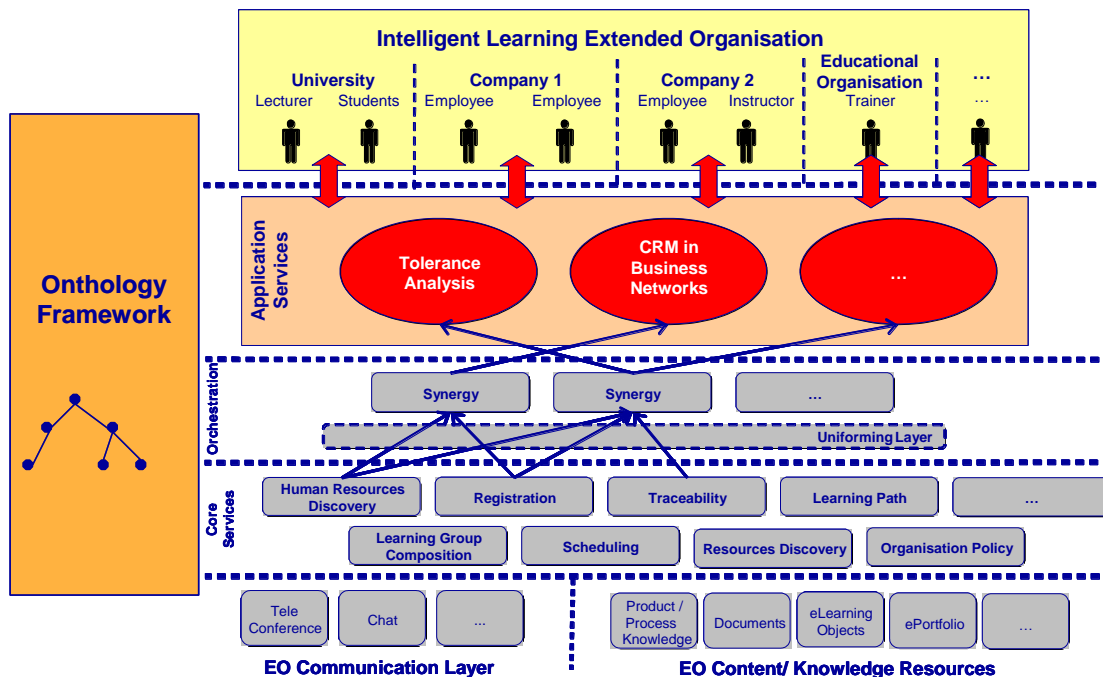


Figure 2 – Targeted architecture (EO stands for "extended organization")

Pedagogical Baseline

The IntelLEO framework relies on *knowledge conversion modes* (Nonaka and Takeuchi, 1995) to pedagogically characterize cross-institutional knowledge-building situations, Figure 3. The upper left quadrant, *socialization of tacit knowledge*, refers to the situation in industry and in an educational institutions where individuals are prompted to accumulate knowledge in an apprenticeship manner, through physical proximity with colleagues, and transfer the tacit knowledge they have acquired from others to their own mental frameworks. To support this, IntelLEO services must be provided to enable access to the organization view and objectives that help individuals to direct their efforts (organization policy services). For example, in a company and at a university certain organizational objectives and rules must be accessible from systems as learning resources.

The upper right quadrant, *externalization of tacit knowledge into explicit*, denotes processes where individuals articulate tacit concepts or create new concepts. They do it through abductive thinking and by using various metaphors, models, diagrams, and prototypes. These are mostly an individual process that can be technologically mediated by rules (organization policy services), harmonized to a certain extent between the industry and universities as learning resources. Likewise, a certain standardized and possibly visual language such as IMS LD (2003) can be provided/used to capture the specifics of the unit of learning and enables instructional designers to express various pedagogies.

Intelligent Learning Extended Organisation

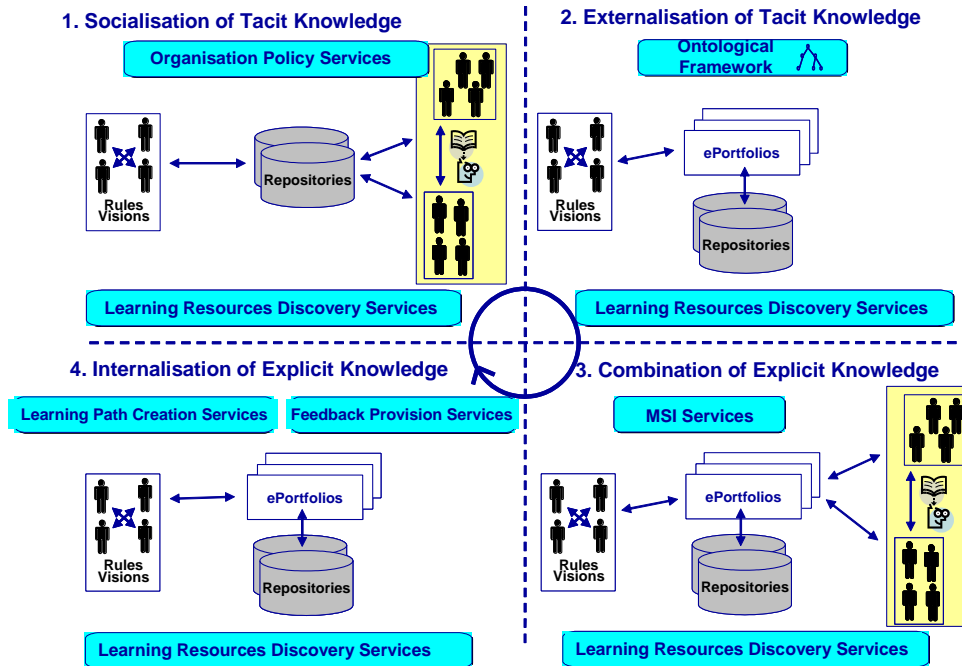


Figure 3 – Knowledge conversion modes as the IntelLEO pedagogical baseline (MSI stands for Management of Social Interaction)

Combination of explicit knowledge, lower right quadrant, is related to primarily group-based activities used to transfer individual knowledge objects across institutional boundaries and system repositories (Carlile, 2004). For example, this may mean to provide an open cross-institutional access to the various individual knowledge objects. Technically, this can be solved using mechanisms of social information filtering and retrieval (but taking into account organizations' IPR policies), as well as human resource discovery (e.g. mentor and co-learners), group composition, feedback-generation, and traceability services. These services facilitate cross-border work for LKB and support storing of knowledge objects in the group context. Learning resources that support LKB should be proposed, oriented towards problem solving and suggesting activities aimed to help the learner reflect on the solution process devised, on the difficulties found, and on more important steps to be carried out in solving the problem.

Internalization of explicit knowledge, lower left quadrant, comes as a result of personal learning from activities the individuals have participated at. It must be supported via self-reflection systems, e.g. within portfolio services. These systems could support personal planning of learning objectives that can be monitored and scaffolded via conversational activities within industry and within an educational institution, in which the learner takes different roles. Services to support this include learning planning and monitoring, feedback generation, human resource discovery, and (personalized) learning path generation.

Project Methodology and Expected Outcomes

The IntelLEO project's technology will provide various application services to support LKB activities in specific contexts, in different teams of an IntelLEO. The project targets a platform open for various services to support both training on the job in industry and students at universities, and to allow for involvement of different actors (different staff levels from shop floor workers up to technical staff and management, but also lecturers from universities and training service providers and individual trainers). Various learning topics are addressed in BCs, and the project solutions will not be restricted regarding the learning content/knowledge topics.

The project will also develop criteria to measure organization responsiveness and increase of motivation at three levels: individual, organizational, and socio-economical.

In order to bring the advanced IntelLEO project deliverables to the related industrial/academic community, the project team plans to conduct extensive demonstration activities in the last phase of the project, as the proof of the viability of the new technologies and services developed. As the three BCs to be supported will be one of the main results of the project, the target for the demonstration activities will be the IntelLEO services operating in real workspaces of the three specific IntelLEOs.

The main outcomes of the IntelLEO project will be: an *implementation framework* to support collaborative LKB and harmonization of individual and organization objectives in an IntelLEO; a set of generic and widely applicable, modular core services; and an empirical analysis of socio-economic contexts in which these services can be best embedded. The project will result in prototype applications (BCs) for all IntelLEO end-users, which will ensure conformity of the solutions and their high transferability to other institutions, both in higher education and industrial domains. However, robust solutions will require up to 2-3 years of subsequent development.

Conclusions

Intelligent Learning Extended Organization (IntelLEO) is an innovative, service-oriented framework for learning and knowledge building (LKB) through collaboration of two or more different organizations coming from business, academic, and other interested communities. The framework includes services to discover, access, manage, and reuse learning resources in the organizations involved, as well as those to harmonize the needs and objectives of the organizations and their individuals. The main issue is to enable effective synergy between the services in order to increase the organizations' responsiveness, defined through increased motivation to proactively learn and construct knowledge. The framework relies on an innovative ontological framework for extensible context capturing, which includes learners, context and collaboration models, and serves to enable exploitation of the synergy between the services. A sound pedagogical baseline and a holistic approach are applied in the IntelLEO framework to support (life long) learning of individuals and organizations. Thus the framework addresses interactions and differences between learning of individuals and that of organizations, and reduces disruptions in the learning processes of individuals (e.g., gaps between universities and working places).

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