Project Number **027023**

**APOSDLE:** Advanced Process Oriented Self-Directed Learning Environment

Integrated Project

IST – Technology enhanced Learning

# Publishable Final Activity Report

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# 1 Publishable Final Activity Report

**Advanced Process-Oriented Self-Directed Learning Environment**

## 1.1 Project Objectives and Research Results in Overview

In a world of rapid change and continuous technological innovation the economy of the European Union relies on the ability of their knowledge workers to learn continuously and especially to apply new knowledge effectively within their work tasks.

The goal of the APOSDLE project was to enhance knowledge worker productivity by supporting informal learning activities in the context of knowledge workers' everyday work tasks and within their work environments. Several activities were pursued to reach this ambitious goal: On the conceptual side, in-depth studies and surveys of knowledge work within a variety of different application domains provided insights into how knowledge workers work and learn at their workplaces, which challenges and bottlenecks they face, and how learning transfer can be measured. We crystallized the insights gained and requirements discovered into the conceptual framework for work-integrated learning support. On the technical side, an iterative prototyping and formative evaluation process with strong involvement of the application partners was conducted. We developed the first comprehensive, domain-independent software framework for work-integrated learning support. On the application side, we turned this software framework into full-fledged learning environments for the application partner organizations by creating application specific models. These application-specific APOSDLE environments were evaluated in a long-term, in-depth summative evaluation within the real work environments of the application partners.

APOSDLE is the first comprehensive, domain-independent software framework which realizes the work-integrated learning paradigm: It supports informal learning activities in the context of knowledge workers' everyday work tasks (instead of within isolated learning modules), within their computational work environments (instead of separate learning environments), by utilizing knowledge artifacts and people available within the organization for learning (instead of relying on manually created learning objects). In doing so, APOSDLE tightly intertwines learning and working activities, thus coupling knowledge acquisition with knowledge application.

APOSDLE delivered specifically for the area of technology enhanced work-integrated learning:

**Conceptual Framework for Work-integrated Learning (WIL) Support**

**Software Framework for WIL Support**

APOSDLE also contributed significantly to the following research areas:

**Learning Support on different levels of guidance**

**Contextualization: User Context and User Profiles**

**Semantic Models**

**Privacy**

**User-Centered Software Design and Evaluation**

For more details please visit http://www.aposdle.org.

### 1.1.1 Conceptual Framework for Work-integrated Learning (WIL) Support

Results of two empirical studies offer deep insights into how knowledge workers work, learn and collaborate at their workplaces. For instance, we found that in 70% of their learning situations, workers learn from their colleagues, and in 63% they rely on digital resources. In 48% of the observed learning situations, a bottleneck occurred. The most frequent bottlenecks were that workers could not reach their colleagues, the colleagues were not able to help, too much information was available, the information was not sufficient to solve the problem, the information was too general, they did not know where to look for, or finding information cost too much time.

These studies together with an extensive literature and state-of-the-art review were the basis for defining *real-time* learning with *real content* and in the *real computational environment* as the key characteristics and challenges for work-integrated learning.

From a learning perspective, the key distinctions of APOSDLE as compared to other systems are that APOSDLE provides integrated support for the learner, knowledgeable person and worker, and that it assists with learning activities within work and learning processes. Moreover, learning support within APOSDLE is integrated in the users' (computational) work environment and utilizes organizational memory thereby maximizing learning transfer.

Key Publications and Deliverables

Lindstaedt, S. N., Aehnelt, M., de Hoog, R. (2009) **Supporting the Learning Dimension of Knowledge Work** in: Cress, U., Dimitrova, V., Specht, M. (Eds.): Learning in the Synergy of Multiple Disciplines, 4th European Conference on Technology Enhanced Learning, EC-TEL 2009, Nice, France, September 29 - October 2, 2009, 639-644

Kooken, J., Ley, T., de Hoog, R. (2007) **How Do People Learn at the Workplace? Investigating Four Workplace Learning Assumptions** in: Duval, E., Klamma, R., Wolpers, M. (Eds.), Creating New Learning Experiences on a Global Scale (LNCS, Volume 4753), 158-171, 2007, Springer, Heidelberg

APOSDLE D2.1: **Workplace Learning Study**, 2006. [Link]

APOSDLE D2.5: **Workplace Learning Study 2**, 2008. [Link]

APOSDLE D2.8 – 3.5: **The APOSDLE Approach to Self-directed Work-integrated Learning**, 2009. [Link]

APOSDLE D2.12: **Conceptual Architecture including Component Evaluation**, 2010. [Link]

### 1.1.2 Software Framework for WIL Support

Based on these theoretical considerations, a proof-of-concept software framework for work-integrated learning (WIL) support was developed. The APOSDLE framework utilizes a knowledge base consisting of three interrelated semantic models and annotated documents (text as well as multimedia, named knowledge artefacts) from the organizational memory (e.g. project reports, documentation, meeting minutes). In order to support a user the following interoperable services are provided. They are shortly mentioned here and described in more detail in the sections below.

APOSDLE Context Detection Services automatically recognize the user's work context (current work task, prior knowledge) based on user interactions and automatically maintain the user profile. Based on this user profile, the APOSDLE Recommender Services suggest parts of knowledge artifacts (named snippets) from the knowledge base which are relevant to the user's current work task and applicable to her competencies. Other APOSDLE Recommender Services additionally suggest people within the organization who have similar or more advanced skills than the user. APOSDLE Collaboration Services provides scripted support for collaboration between a knowledge seeker and a knowledgeable person. The collaboration transcripts can be shared with others via the APOSDLE

framework and can be fed back into the knowledge base. In addition, APOSDLE provides a variety of Learning Guidance Services (e.g. learning path service).

The APOSDLE framework combines semantic approaches with 'soft computing' methods such as associative retrieval, statistical methods and heuristics. Soft computing methods provide good results in the presence of uncertainty and the absence of fine granular models. The APOSDLE framework also implements hybrid approaches to user context detection, user profile management, context-based recommendation and awareness building, automatic identification of similarities based on text or multimedia data, expert identification, etc. These technical achievements position the APOSDLE framework not only within the TEL community but also impact the wider field of computer science.

Key Publications and Deliverables

Schmidt, A., Hinkelmann, K., Ley, T., Lindstaedt, S. N., Maier, R., Riss, U. (2009). **Conceptual Foundations for a Service-oriented Knowledge and Learning Architecture: Supporting Content, Process, and Ontology Maturing**. Pellegrini, T., Auer, S., Tochtermann, K., Schaffert, S.: Networked Knowledge - Networked Media Integrating Knowledge Management, New Media Technologies and Semantic Systems, Studies in Computational Intelligence, 221, 79-94, Springer

Lindstaedt, S. N., Ley, T., Scheir, P. & Ulbrich, A. (2008). **Applying Scruffy Methods to Enable Work-integrated Learning**. In: Upgrade: The European Journal of the Informatics Professional, 9 (3), 44-50.

Lindstaedt, S.N., Scheir, P., Lokaiczyk, R., Kump, B., Beham, G. & Pammer, V. (2008). **Knowledge Services for Work-integrated Learning**, In: *Proceedings of the 3rd European conference on Technology Enhanced Learning: Times of Convergence: Technologies Across Learning Contexts*, Heidelberg: Springer Verlag, pp. 234-244.

APOSDLE D4.11: **Final System Architecture for 3rd APOSDLE Prototype**, 2009. [Link]

APOSDLE DP3: **Third Prototype APOSDLE** (2010) [Link]

### 1.1.3 Learning Support on different levels of guidance

To support users in different roles (learner, worker, knowledgeable person) and different situations, APSODLE provides varying degrees of learning guidance.

First, APOSDLE provides informal learning support by suggesting knowledge artifacts (text as well as video) based on the current work task of the user and her prior knowledge (skills), or by recommending knowledgeable people. Thus, APOSDLE supports its users in performing their work task without them even having to type a query. Moreover, their own level of expertise is taken into account when making suggestions. This unobtrusive proactive information delivery raises *awareness* of knowledge resources (documents as well as people) the users would not have searched for otherwise. Second, by exposing the relationships between topics and tasks of the application domain the learner is enabled to explore the underlying formal knowledge structures and to learn from them. Specifically, users can be made aware of topics relevant to the current task. These might constitute relevant learning goals for the future. In addition, APOSDLE supports communication between peers by helping to identify the right person to contact, to select the preferred communication channel, to contextualize the cooperation, and to document it if desired. It is up to the user when, in which situations, and in which order to take advantage of this support. Third, APOSDLE explicitly supports learning in context with resources (text, video) via learning hints. In addition, the creation of learning paths for longer term and more systematic competency development is supported and partially automated. The time and method of learning path execution is not predetermined and can be performed flexibly.

Key Publications and Deliverables

Lindstaedt, S.N., Kump, B., Beham, G., Pammer, V., Ley, T., Dotan, A., de Hoog, R. (2010). **Providing Varying Degrees of Guidance for Work-Integrated Learning**. Wolpers, M., Kirschner, P.A., Scheffel, M., Lindstaedt, S.N., Dimitrova, V.: Sustaining TEL: From Innovation to Learning and Practice, Proceedings of EC-TEL 2010, Springer.

Godehardt E., Schneider C., Lokaiczyk R., Faatz A. (2009). **Contextualized Visualization at the Workplace**. The International Conference on E-Learning in the Workplace (ICELW 2009), New York, USA, 10 June 2009.

Aehnelt, M., Ebert, M., Beham, G., Lindstaedt, S. N., Paschen, A. (2008). **A Socio-Technical Approach towards Supporting Intra-Organizational Collaboration.** Proceedings of the European Conference on Technology Enhanced Learning (ECTEL) 2008, Maastricht, The Netherlands, September 16-19, 33-38.

Bonestroo, W., Ley, T., Kump, B., Lindstaedt, S. N. (2007) **Learn@Work: Competency Advancement with Learning Templates** Martin Memmel, Eric Ras, Martin Wolpers, and Frans Van Assche (Eds.), Proceedings of the 3rd Workshop on Learner-Oriented Knowledge Management, 9-16, RWTH, Aaachen.

APOSDLE DP3: **Third Prototype APOSDLE - Learning Tools Part** [Link]

### 1.1.4 Contextualization: User Context and User Profiles

Within APOSDLE, we have approached the topic of contextualization from two angles: First, we provided different user context detection services for the automatic discovery of the users' work tasks and topics based on user interactions. For this purpose, system sensors and other applications were developed that observe each user's interaction context at the PC/Laptop. Second, we have conceptually designed and implemented user profile services that make automatic inferences of a user's prior knowledge based on naturally occurring interactions which are interpreted as knowledge indicating events (KIE). Therefore APOSDLE observes KIE during daily work within authentic computational work environments and decides for each topic in the learning domain which knowledge level (beginner, advanced, expert) a user has in this topic. The diagnosis of prior knowledge of a user thus happens non-invasively without self-assessment or testing. An innovative visualization of user profile data in the sense of an open learner model has been developed that allows users to view their own profiles and edit them, if desired.

Key Publications and Deliverables

Lindstaedt, S. N., Beham, G., Kump, B., & Ley, T. (2009). **Getting to Know Your User – Unobtrusive User Model Maintenance within Work-Integrated Learning Environments**. In: U. Cress, V. Dimitrova, Specht M.: Learning in the Synergy of Multiple Disciplines: Proceedings of the 4th European Conference on Technology Enhanced Learning (EC-TEL 2009), 73-87, LNCS 5794, Springer. Best Interdisciplinary Paper Award

Ley, T., Ulbrich, A., Scheir, P., Lindstaedt, S. N., Kump, B., Albert, D. (2008). **Modelling Competencies for Supporting Work-integrated Learning in Knowledge Work**. Journal of Knowledge Management, , Vol. 12, Issue 6, 31-47. Best Paper Award

Robert Lokaiczyk, Andreas Faatz, Arne Beckhaus, Manuel Görtz (2007): **Enhancing Just-in-Time E-Learning Through Machine Learning on Desktop Context Sensors**. CONTEXT 2007:330-341

APOSDLE D2.12: **Conceptual Architecture including Component Evaluation**, 2010. [Link]

### 1.1.5 Semantic Models

The APOSDLE framework is domain independent insofar as it can be customized to new learning domains by creating semantic models of work tasks, required knowledge, and learning topics. Semantic models hold most of the “intelligence” of the APOSDLE framework. They are used for user profiles, for navigation through resource, and for semantic search and resource recommendation. The latter (search and recommendation) is based on a two layer associative network that uses both semantic and text based similarity measures for retrieval.

To support non-expert knowledge engineers (employees of the respective company) with the creation of these semantic models an Integrated Modeling Methodology (IMM) and a Modeling Wiki (MoKi) were developed. The IMM supports non-expert knowledge engineers by providing guidelines on how to elicit knowledge from domain experts and on how to create interlinked models describing work tasks, required knowledge and learning topics. The MoKi is a collaborative process and domain modeling tool. By modeling all aspects of the learning domain (work tasks, required knowledge, learning topics) in a single computational environment, coherence between these aspects is ensured. MoKi can automatically suggest domain concepts based on term extraction from text documents. Furthermore, MoKi triggers incremental refinement of models by giving users feedback on current models. The models created in the MoKi can be exported into OWL and BPMN format. MoKi is drawing a larger user community including companies and public organizations dealing with the topics of organic agriculture, chemistry, risk-and disaster management, innovation management, electromagnetic simulation, and requirements engineering.

Key Publications and Deliverables

Pammer, V., Kump, B., Ghidini, C., Rospocher, M., Serafini, L., & Lindstaedt, S. N. (2009). **Revision support for modeling tasks, topics and skills**. In Paschke, A., Weigand, H., Behrendt, W., Tochtermann, K., Pellegrini, T.: Proceedings of I-Semantics ’09, 5th International Conference on Semantic Systems, 501-508.

Rospocher, M.; Ghidini, C.; Pammer, V.; Serafini, L. & Lindstaedt, S. (2009) **MoKi: The Modelling Wiki** Proceedings of the Forth Semantic Wiki Workshop (SemWiki 2009), co-located with 6th European Semantic Web Conference (ESWC 2009), 2009, 464, 113-128

Ghidini, C., Rospocher, M., Serafini, L., Kump, B., Pammer, V., Faatz, A., Zinnen, A., Guss, J. & Lindstaedt, S. (2008). **Collaborative Knowledge Engineering via Semantic MediaWiki.** In Proceedings of I-Semantics 2007, International Conferences on Semantic Systems as Part of (Triple-I 2008), pp. 134-141.

Scheir, P., Lindstaedt, S.N., & Ghidini, C. (2008). **A Network Model Approach to Retrieval in the Semantic Web**, In: A. Sheth (Ed.), International Journal on Semantic Web and Information Systems, Vol. 4, Hershey, PA, USA: IGI Global Publishers, pp. 56-84.

APOSDLE D1.6: **Integrated Modelling Methodology Version 2**, 2009. [Link]

### 1.1.6 Privacy

Privacy provision is especially challenging for WIL- systems, because sensitive data is collected. It needs to be ensured, that no fragments of individual user profiles are distributed throughout the system or exchanged among users. In particular, privacy management for cooperative activities is a key issue that must be addressed.

APOSDLE includes a sophisticated privacy concept and provides an extensive set of innovative features to solve very critical legal, socio-technical and purely technological aspects of adaptive WIL-based systems like APOSDLE. The APOSDLE framework utilizes a centralized, service-oriented, standardized policy-based engine called the Privacy Enhancement Service (PES) to ensure a privacy-

protected access control and filtering of personal information flow. The management of cooperative activities and group information implies privacy violations to some extent. For example, users must share personal information to proactively establish communications or to share common interests. Within this context, our solution of Rooms & Shares supports users in negotiating mutual levels of privacy protection, so they can take control over common spaces and resources.

Key Publications and Deliverables

Garcia-Barrios V.M., Beham G., Kump B. (2008). **Scrutinising Competencies: Retraceable Clouds of Learning Goals in the APOSDLE System**. In Proceedings of 6th International Conference on Community Based Environments: OpenACS and .LRN Conference 2008, February 2008, Guatemala, ISBN 978-99922-2-434-2, pp. 34-45.

Zinnen A., Hambach S., Faatz A., Lindstaedt S., Beham G., Godehardt E., Goertz M., Lokaiczyk R., (2008). **Datenschutzfragen bei der Etablierung einer Arbeitsprozess-integrierten e-Learning-Lösung**, DeLFI 2008: 6. e-Learning Fachtagung Informatik, Lübeck, Germany, 7-10 September 2008

APOSDLE D1.7: **Privacy in APOSDLE**, 2009.

### 1.1.7 User-Centered Software Design and Evaluation

The development of APOSDLE was strongly driven by a user-centered design and evaluation process. The design process included innovative approaches of requirements engineering. It consisted of instances of synchronous and asynchronous, distributed and non-distributed design activities, and also integrated activities designed to stimulate creative inputs to requirements. The design activities also included mock-ups and iterative prototyping, and iterative use case writing and creativity workshops resulting in 22 use cases and more than 1000 requirements.

Formative evaluations of the second prototype lead to a re-design of APOSDLE using the personas approach. Extensive usability studies were carried out with students, application partners in real world settings and usability labs, and a variety of evaluations of individual components was carried out. A final summative evaluation spanning three months of real-world application concluded the process.

Key Publications and Deliverables

Lichtner V, Kounkou A, Dotan A, Kooken J, Maiden N (2009) **An online forum as a user diary for remote workplace evaluation of a work-integrated learning system**, CHI2009, April 4-9, Boston, MA

Dotan A, Maiden N., Lichtner V. and Germanovich L, (2009) **Designing with Only Four People in Mind? – A Case Study of Using Personas to Redesign a Work-Integrated Learning Support System**, INTERACT 2009 - 12th IFIP TC13 Conference in Human-Computer Interaction, August 24-28, 2009 in Uppsala, Sweden.

Jones, S., Lynch, P., Maiden, N., Lindstaedt, S. N. (2008) **Use and Influence of Creative Ideas and Requirements for a Work-Integrated Learning System** in: Proceedings of the RE08, 16th International Requirements Engineering Conference, Barcelona, Catalunya, Spain, September 8-12, 289-294, IEEE Computer Society Press

APOSDLE D6.4: **APOSDLE Use Scenarios & Requirements for 3rd Prototypes**, 2008. [Link]

APOSDLE D6.12: **Summative Evaluation Report**, 2010. [Link]

### 1.1.8 Real-World Application and Summative Evaluation

The APOSDLE framework was successfully embedded within four companies (EADS, Center of Commerce and Industry Darmstadt, ComNetMedia, and ISN) and applied to a variety of learning domains such as electromagnetic simulation, innovation management, IPR management, REACH consulting, requirements engineering, statistical data analysis, etc.

A summative evaluation examined the extent to which the main objectives (supporting learning, working and collaborating) of the project and the application partners have been satisfied by the APOSDLE solution. The evaluation was carried out at the Application Partners' sites. It took about three months and involved nineteen persons. A multi-method data collection approach was followed using a questionnaire, interviews, log data, user diaries kept while working with APOSDLE, and site visits. This allowed for triangulation of results.

The conclusion of the summative evaluation is that the APOSDLE solution has proven very useful for learners in highly-specialized domains such as EADS's Electromagnetism Simulation domain in which much of the knowledge to be learned is documented. In those circumstances, APOSDLE delivered an effective work-based learning solution that enabled relatively inexperienced knowledge workers to efficiently improve their knowledge in various ways. However, it proved less effective in broad customer-driven domains where knowledge was shared to a large extent in person and is typically not documented.

Experts in all three application sites perceived APOSDLE as a tool aimed mainly at learners or novices in the domain. They valued its benefit as a training tool but regarded it as a tool they did not need to do their work. They acknowledged their role was to contribute high quality learning material (e.g., Snippets, documents and Learning Paths). However, we note that during summative evaluation only a limited number of experts were involved and the knowledge base stayed static, which we perceive as potential reason for this result. Further research work is required to reach comprehensive conclusions here regarding the learning support at work desired and needed by experts.

Finally, we conclude that the APOSDLE approach partly worked. Relying on existing material instead of tailor made learning material proved to be effective and cost efficient. Crucial for this is the availability of good modeling tools, experienced modelers, and high quality annotations of snippets. Providing domain independent learner support was less successful as most of the provided features were hardly used. Probably the gap between the generalized and rather abstract nature of these features and the very specific context of work is too large. Further research work is required to examine if putting more effort in good annotations will bring more benefits than trying to refine or enhance specific learner support.

Christl, C., Ghidini, C., Guss, J., Lindstaedt, S. N., Pammer, V., Scheir, P., Serafini L. (2008). **Deploying semantic web technologies for work integrated learning in industry. A comparison: SME vs. large sized company**. Sheth, A. et al. (eds): Proceedings of the ISWC 2008, 7th International Semantic Web Conference, Karlsruhe, Germany, Oct 26-30, 2008 , 709-722, Springer

APOSDLE D6.12: **Summative Evaluation Report**, 2010. [Link]

 

## 1.2 Exploitation and Dissemination of Project Results

Exploitation was and is (partly, exploitation activities are still ongoing after the end of the project) based on the APOSDLE framework as holistic workplace-integrated learning solution as well as on particular APOSDLE components and the modeling methodology. The consortium decided to let many partners seed the components, services, software and methodologies from four years of research and development. This was possible through the clear ownership of mature components on the one hand and the **open source** solution on the other hand, which situation also **makes dual (commercial-non-commercial) licensing models possible**. The customer-oriented exploitation of this full environment was a mission driven by the application partners of the APOSDLE consortium, but also research partners carried out exploitation activities.

Due to the technical maturity of the APOSDLE prototype, a **public APOSDLE demonstrator**[1] complements the marketing, market research, and demonstration activities of the network and provides in-depth contact points after first business contacts.

Furthermore, at the time of writing, the complete APOSDLE system is being actively used at the library of the Distance University Hagen to train library employees. We have also built a mobile version of APOSDLE on the iPhone. User context detection and semantic annotation functionalities out of APOSDLE were adapted to the situation of supporting enterprise processes together with Know-Center's partner IMC.

Links to other EU projects and activities were established by founding the EATEL Special Interest Group on Professional TEL (SIG ProTEL, based on the Professional Learning Cluster), being involved in STELLAR, and being invited by other EU projects for presentation (e.g. MATURE, ACTIVE). Additionally, APOSDLE serves as one of the baselines for the FP7 IP project MIRROR. Continued usage and development of MoKi is carried out within the EU project PESCADO. In terms of dissemination to the external world, the project therefore continues to be successful in creating visibility in the technology enhanced learning and knowledge management communities.

APOSDLE D7.6: **Exploitation Activities**, 2010.

[1] http://aposdle-sda.know-center.tugraz.at/demo/

## 1.3 APOSDLE Consortium

The APOSDLE consortium consists of 12 organisations from 7 different European countries, ensuring that the demands of the ambitious vision of the project can be met both in terms of complementary competences and in terms of broad access to different technologies and domains of application.

JOANNEUM RESEARCH, Austria

Know-Center, Austria

SAP, Germany

Technical University Graz, Austria

Fraunhofer Gesellschaft, Germany

University of Twente, Netherlands

City University London, United Kingdom

Fondazione Bruno Kessler, Italy

EADS France, France

isn - Innovation Service Network, Slovenia

ComNetMedia, Germany

Chamber of Industry and Commerce – Darmstadt, Germany

## 1.4 APOSDLE Contact Persons

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