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Basic LMS Architecture for Learner-Centric LearnFlows or How Reusable Learning Objects Fit into Co-Constructivist Learning Processes

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Abstract

The discussions about learning management systems and reusable learning objects primarily focus on technical standardization issues. Standards such as SCORM or LTSC-LOM will yield benefits for content maintenance and exchange of learning objects between publishers, services providers, and technical platforms. Pedagogic questions, e.g., how standardized learning objects can be used to guide learners through a number of learning experiences towards enhanced levels of knowledge and competency, are neglected. Furthermore, there are competing standards and the complexity of processes, subsystems, and functions in learning systems will make the implementation of standards challenging. The paper outlines the present state of standardization efforts and confronts technical standards with the complexity of a learning model for adult learners. It is proposed to use a workflow/learn-flow engine as a core module of learning management systems together with different types of learning objects. Functions and processes of a learn-flow driven LMS are outlined.

1 Introduction

Digging into the dynamically growing number of papers about (reusable) learning objects (RLOs), e-learning standards, and learning management systems (LMSs), an obvious question arises: “Where is the learning in e-learning?” [Koper-2001] Frequently the discussion centers around technical aspects of LMS-independent structuring, packaging, and exchange of learning content. This technical perspective of learning objects -- and the accompanying standardization efforts -- will yield benefits for content maintenance and the exchange of learning objects between publishers, educational services providers, and technical platforms in the coming years.

At the same time, the technical focus on the development of easy to re-deploy, reuse, and maintain learning objects might negatively affect attainable learning results. Referring to the need of learning within a rich (simulated) real-life context, Allen suggests that there might be a trade-off between LO maintainability and context-related learning – which requires more complex RLOs: He provocatively asks: “Is lowering the quality of e-learning a fair trade-off to ease maintenance?” [Allan-2003, 51-52]

In addition, Clark/Mayer point to the results of a large number of empirical media comparison studies (the US Army started as early as 1947), which indicate that the type of media used in instruction does (in most cases) not have an effect on learning outcomes: “When the instructional methods remain essentially the same, so does the learning, no matter how the instruction is delivered.” [Clark/Mayer, 20] Therefore, the use of RLOs per se – regardless of how appealing the presentation of content is to a learner – can only play a limited role within the framework of a more complex and holistic learner-centric pedagogical process and will not guarantee learning success.

From a historical perspective, it seems that we are progressing in phases [Koper-2000, 14]: Initially instructional designers focused on the selection and organization of content. Then the “message design” – the form in which the content was delivered to the learner – drew attention, while at present the focus is on “systems of human activity that are focused on reaching (learning) objectives”. [Koper-2000, 14] After a first and second phase of excitement about new ICT (information and communication technology) tools for Internet learning and multimedia presentation, the focus is now reverting back to human learning (“making sense of the world”) and instruction (“aiding that sense making”) - in the third phase e-learning is being approached from a situated cognition perspective. [Duffy-2001]

While there is an “undying optimism that just around the corner is an easy way to create meaningful ... learning experiences that swiftly change human behavior, build skills, and construct knowledge” a significant amount of research work in the area of e-learning systems development and e-andragogy still lies ahead [Allen-2003, 50] Clearly, the present-day discussion of e-learning must incorporate the assumption that e-learning systems comprise a set of tightly interwoven elements and subsystems with demanding complexity and relationships which are not yet fully understood.

Even if it is assumed that understanding the complexity of e-learning systems and learn-flows requires additional research, there is an urgent need in making plausible assumptions about ICT-based learning: The pressure is mounting to design complex LMSs for efficiently conveying knowledge together with real life context to a dynamically growing number of individual learners – who frequently will be working adults with a rather checkered conglomerate of knowledge and qualifications. Given the increasing number of participants in e-learning courses, instructional designers must work towards developing sequences of learning experiences (learning processes, learn-flows) – supported by RLOs – which can be adapted to the diverse learning requirements of the individual learner and his actual cognitive and situational needs. Technology can be the enabling factor to enhance and enrich these learning experiences and learn-flows but can not supplant pedagogical concepts.

The goal of this paper is to outline an architecture for LMSs which is based on standardized RLOs and allows for learner-centric and personalized learning processes (learn-flows based on "simple" learning objects) within the framework of a specific pedagogical concept (co-constructivist mastery learning -- a learning process designed for adult learners). [Finke-2000, 120] In the context of this paper, learning objects will be defined as the "smallest unit of learning that can be automatically managed and tracked...(and that) can be used to construct any desired type of learning experience." [Fallon/Brown-2003, 6]

At first, the present state of the learning objects standards discussion and the relevant elements of the co-constructivist progressive mastery learning (CCPML) concept will be outlined. Then, we will examine the architectural requirements for RLO-based personalized learn-flows in CCPML. The focus will be on exploring a pragmatic architecture which holds the potential to combine technical constructs (RLOs) with process-oriented pedagogical concepts.

With regard to standardization efforts and the goal of RLO independence from specific platforms, it must be noted that complex learn-flows will lack standardization for the foreseeable future and thus, portability problems will continue to increase. Nevertheless, Koper is already trying to lay the groundwork for the future standardization of complex educational settings and processes by defining a “notational system with which a learning environment ... can be fully described.” [Koper-2000, 24, 26]

2 Reusable Learnig Object Standardisation

There are a number of organizations involved in the development of e-learning standards. Sometimes these organizations are working in parallel and their activities overlap considerably. Major standards bodies are: [Fallon/Brown-2003, 32-38]

- AICC – Aviation Industry CBT Committee (CBT Guideline; CMI Guidelines for Interoperability between Web-based courseware and LMSs; AGRs Guidelines and Recommendations)
- ADL – Advanced Distributed Learning Initiative (CAM Content Aggregation Model, RTE Run-Time Environment, SN Sequencing and Navigation; SCORM Sharable Content Object Reference Model) [ADL-2004, 1-3]
- IMS Instructional Management Systems Project – IMS Global Learning Consortium (Learning Resources Meta-Data Specification, Content and Packaging Specification, Question and Test Interoperability Specification, Learner Profiles Specification, Simple Sequencing Specification)
- IEEE/LTSC – Institute of Electrical and Electronics Engineers – Learning Technology Standards Committee (LOM Learning Objects Metadata Schemas)
- DCMI – Dublin Core Metadata Initiative (Dublin Core Metadata Record, metadata standards for RLO discovery across domains, metadata interoperability frameworks) [Dublincore-2004]
- ARIADNE Foundation – Alliance of Remote Instructional Authoring and Distribution Networks for Europe.

While the number of different organizations working towards e-learning standards and the complexity of their proposed concepts are challenging, there is significant cooperation amongst them. ADL was founded by the U.S. Department of Defense and the White House Office of Science and Technology Policy and its SCORM project tries to “... integrate ... (the works of other organizations) with one another to form a more complete and easier-to-implement model.” [ADL-2004, 1-3, 1-7] The “SCORM Books” draw on the following standards [ADL-2004, 1-27]

- ·Content aggregation model – metadata derived from IEEE LOM 1484.12, content structure derived from AICC, content packaging and sequencing model derived from IMS
- ·Sequencing and navigation – sequencing information and behavior derived from IMS
- ·Run-time environment – based on IEEE API 1484.11.2, IEEE Data Model 1484.11.1.

At the same time, there is additional synergy because the individuals involved in the process of standardization often serve in committees of several standards bodies simultaneously. [Fallon/Brown-2003, 38] Nevertheless, ultimate standardization goals are lofty and will be difficult to attain: E.g.; assuming that – in the long range – RLOs will be available via the Internet in large numbers, ADL aims at providing the standards to allow for “discovery, selection and assembly (of RLOs) in real time, on demand” -- in this vision, intelligent tutoring/decision aiding and “tailored adaptive instruction” will be accomplished via server functions. [ADL-2004, 1-11, 1-12]

Fig. 1 gives an example which outlines relationships between ICT functions/subsystems of learning systems and selected standards for content structuring and transmission: The learning content management system (LCMS) – containing the content repository – could be based on ADL-SCORM or on AICC-CMI. In the case of an ADL-SCORM-based system, the content aggregations contain “sharable content objects” (SCOs -- the RLOs in the SCORM content aggregation model), the assets (e.g., multimedia objects used by SCOs), and the manifest (“meta-data specification”), which describes the content aggregation. [Fallon/Brown-2003, 9]

To design and package SCOs, appropriate development and authoring tools are required (e.g., MacroMedia Authorware, IBM Authoring Tool). [IBM-2003a] For course deployment SCOs are transferred from the LCMS to the LMS via modules which conform to the AICC packaging and communication standards. LMSs have functions for the deployment of courses, learner registration etc.. [IBM-2003b] RLOs are able to communicate with the LMS via JavaScript calls. [Fallon/Brown-2003, 57] While there are standards for simple types of assessments (IMS QTI – Question and Test Interoperability), standards for learning process supervision and management provide rather basic functionality: Individual learner behavior (e.g., time spent working on a RLO or test results) is tracked by the RLO and communicated to the LMS. [IBM-2003a, IMS-2001, 10]

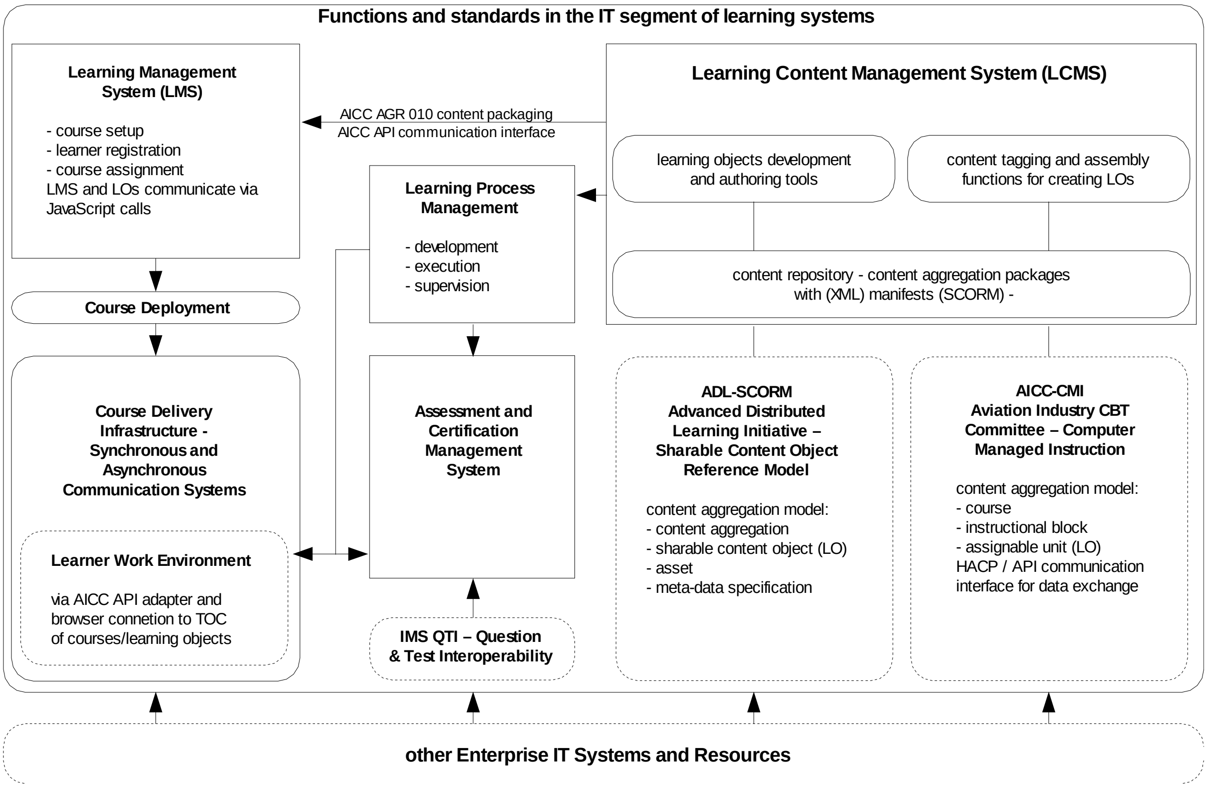

Figure 1: Functions and standards in the ICT segment of learning systems

In January 2004 ADL added its “Sequencing and Navigation: Rules and Behaviors” to the SCORM 1.3 specifications. [ADL-2004, 1-6, 1-27] IMS is the source of the SCORM sequencing concept, and the intention is to provide LO designers with the means to define the “relative order in which elements of content are to be presented to the learner and the conditions under which a piece of content is selected, delivered, or skipped during presentation” -- which clearly refers to micro-control structures in a larger competency-gap-bridging learning process. [IMS-2003] The AICC CMI data model was the starting point for the ADL data model for collecting learning process data (e.g., student ID and name, time spent while working on a LO) and its complexity was sharply reduced by ADL. [Fallon/Brown-2003, 59] IMS seems to have a different agenda and published its “Learner Information Specifications” in March 2001 [IMS-2001-b] These specifications propose a learner data model with considerable breath and differ substantially from the AICC or ADL data models. IEEE LTSC and the Dublin Core Metadata Initiative (DCMI) have joined forces to integrate their metadata models to offer yet another learning objects metadata standard. [Dublincore-2000]

The discussion about the evolving standards for RLOs and LMSs outlines the present situation: The focus of learning systems standardization is on "simple" technical aspects – mainly the structuring of digital content, its transfer between subsystems of the technical segment of learning systems, the delivery, presentation and sequencing of content to the learner, and the electronic assessment of learning results. In addition, standards bodies seem to have different agendas and their work influences different market segments: Via the the U.S. Department of Defense – with its overwhelming purchasing power -- ADL SCORM will exert strong influence on the RLO- and LMS-market segments for the U.S. military, U.S. government organizations, and defense contractors.

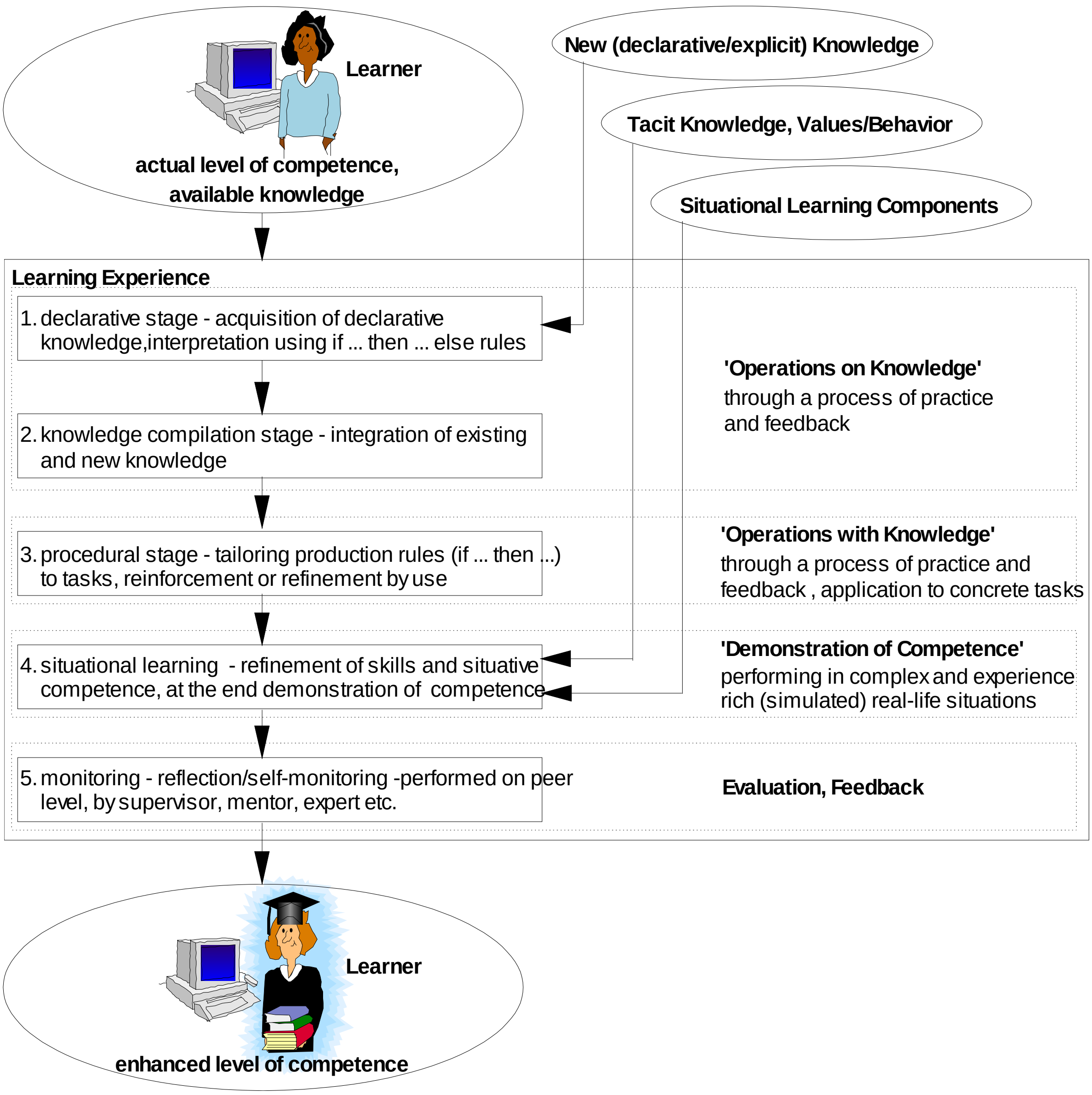

Figure 2 - Learning experience as a cognitive process

The AICC standards will be the center of gravity for the aviation industry – because of the large number of already available AICC compliant RLOs and LMSs. The Western Governors' Association with its huge potential in the higher education e-learning market recently decided to embrace a broad spectrum of standardization activities after having been biased towards IMS for a number of years. [WGA-2003] MIT's Open Knowledge Initiative (OKI) works together with ADL and IMS to "... close the gap between innovative pedagogical technology and production learning resources". [UofI-2001] OKI's Open Service Interface Definitions (OSIDs) provide a "plug and socket" standard and aim at interfacing learning object repositories to any e-learning application. Last-but-not-least there is a considerable gap to bridge between the agreement on standards and a complex fully functioning e-learning infrastructure for operational use. The whole situation is confusing at best and decision makers in industry and higher education face severe problems when they need to decide on which standards the costly production of RLOs should be based.

3 Co-Constructivist Learning for Working Adult Learners

After discussing the various technical standardization efforts above, it might look to the reader like heresy to outline the structure of learning processes from the human learning perspective. But we feel that it is necessary to confront the reader with the enormous gap between present standardization efforts and the requirements of human learning processes because these processes – in the end -- need to be supported by LMSs and need to provide individual learners with the resources to ascend to higher levels of knowledge and competency: While the computer and communications layers of e-learning systems play an important role within the whole learning system, learning systems and environments are first and foremost "... social system(s) focused on the permanent development and certification of human knowledge and competencies in a particular domain." [Koper-2000, 10]

The co-constructivist learning model (fig. 2) explained below was developed by the author for adult learners who want to enhance job-related competencies [Finke-2000, 120]. Figure 2 outlines a model for structuring a personalized learning experience – a single step forward on the individual learners more extensive journey towards a higher level of knowledge and competency – as a cognitive process. [Finke-2000, 126]

Before a learner can be confronted with a new learning experience, his/her actual level of competency and corresponding knowledge has to match the prerequisites of the following learning experience (fig. 4, preliminary tasks). The learning experience then is structured into several consecutive steps (fig. 2) in which the learner at first acquires new knowledge (steps 1 and 2 – operations on knowledge) and afterwards (step 3 -- operations with knowledge) applies the knowledge to more theoretical problems to integrate it efficiently with already available cognitive constructs. In step 4 the learner demonstrates his level of competency by tackling (usually simulated) complex real-life problems. Because explicit knowledge (hard facts) sometime might be "only the tip of the iceberg", tacit knowledge ("highly personal and hard to formalize" knowledge) has to be learned or conveyed, too. [Nonaka/Takeuchi-1995, 8] If this is the case, social components of the learning process (interaction with instructors, tutors, or more knowledgeable peers) are indispensable. [Finke-2000, 74; Luckin-1999; Vygotsky-1978]

With regard to the learner/facilitator interaction the process works like this: The teacher/instructor assigns a challenging task (with regard to the learner's present knowledge and competency) to the learner and supports him/her in its completion -- by definition this approach to learning requires challenging tasks and significant human support for the learner to accomplish that task. At the same time the instructor monitors the level of support which the learner needs to complete the assignment. After the learner has successfully completed a learning activity and reached a new level of performance (i.e. demonstrated a newly acquired competency), the next activity is assigned. The decision as to which activity to assign next is based on constantly monitored process parameters. [Finke-2000, 129] Learning facilitator and learners themselves (self-evaluation) are responsible for learning process monitoring, and process results directly influence the assignment of a subsequent learning activity (level of difficulty, complexity, remedial action etc.). The following learning process parameters need to be monitored in the outlined model: [Finke-2000, 131; Luckin-1999]

- Tasks the learner has already successfully completed and the active learning experience (incl. specification of situational task components, values, and professional behavior acquired/demonstrated, group/collaboration/role aspects of the tasks)
- Level of difficulty of the tasks completed and the average difficulty of completed tasks
- Overall level of help needed
- Level of help needed most recently.

4 Learn-Flow Concept for Co-Constructivist Learning Processes

During learning activities, the outlined cognitive learning model must be supported by a suitable pedagogic concept which -- in turn – has to be supported by an (Internet-based) e-learning infrastructure and additional organizational functions, resources, and educational services (e.g., electronic library, electronic learner work environment, administrative student services). The co-constructivist learning model outlined above, is based on the assumption that learners gain additional knowledge or competencies not by the simple reception of blocks of knowledge, but by constructing or re-constructing their individual cognitive concepts and learning to apply them to real-world situations via rich interactivity: Besides access to learning materials (delivered via RLOs), collaboration with other learners, learn teams, learning communities, learning facilitators, or with the complex environment itself are vital ingredients of the co-constructivist learning process.

Based on this view, the focus on learning objects in the e-learning standards discussion can be questioned. RLOs “... act as triggers ...” and can “... support the different kinds of on-line activities and interaction patterns that teachers use ...” but should not mistakenly be seen as the sole component which inspires cognitive processes during learning. [Littlejohn-2003, 2] At the same time there are questions about the validity of the efforts to implement standards for RLOs. At present there is a piecemeal approach to standardization, the standards are growing in complexity, implementation will be challenging and expensive, and the present focus of the whole effort might be questionable.

In the following we will outline a possible approach to an architecture of a learning system, which starts from the perspective of cognitive and pedagogic processes (co-constructivist learning for adult learners).

4.1 Organizational Structure: Responsibilities, Roles and Tasks

As a starting point for an analysis of required IT and communication functions, an organizational concept (structure of interactions between participants) which can support co-constructive learning is outlined below. Based on the learning model explained in fig. 2, a master teacher coaches and manages a number of learning facilitators. He is responsible for curriculums, learner satisfaction, training of facilitators, quality assurance and certification, maintenance of learning content, and the further development of learning concepts.

Learning facilitators interact with individual learners and supervise learn teams. They supervise and act as mentors for learners as required during their work and assign subsequent learning experiences (represented by RLOs) based on the learner's preferences, the performance in preceding learning steps, and the requirements of the individual curriculum.

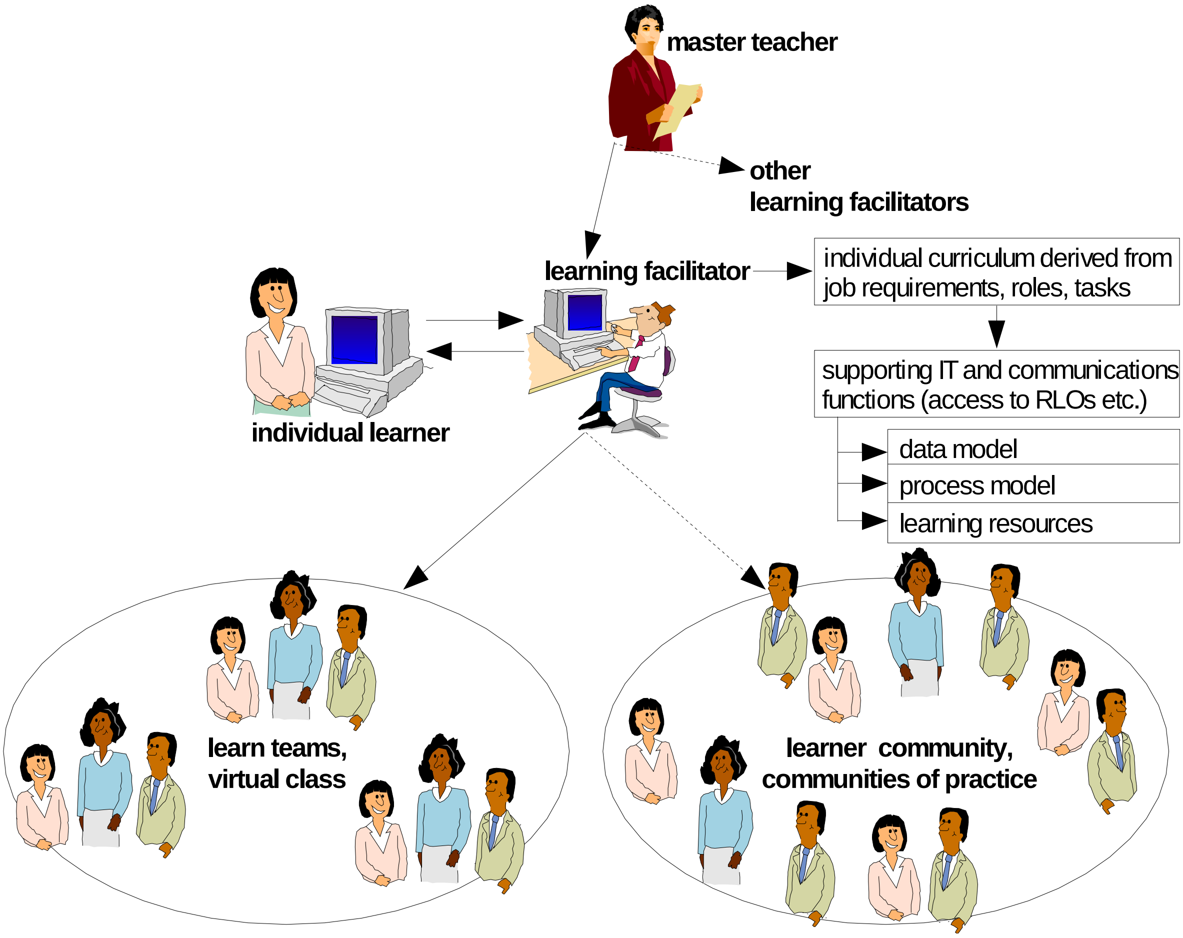

Figure 3 – Responsibilities, roles, and tasks in co-constructivist learning

There can be different types of learning experiences -- hence RLOs: RLOs to enhance knowledge, to integrate newly learned knowledge with existing cognitive structures, to acquire new competencies, or learning experiences/RLOs in which the learner demonstrates the level of competency he has reached in a subject area. The method of instruction comprises the tutoring of individual learners and learn teams on the basis of individual curriculums and challenging assignments. For informal extra curricula learning (e.g., acquiring tacit knowledge) and collaboration with fellow learners or practitioners, facilitators are available who are involved in managing learner communities and communities of practice. Here, the borderline between the role of a learning facilitator and the role of a consultant can blur.

4.2 Learnflow Architecture: Supporting IT and Communication Functions

Human learning can be interpreted as a flow of subsequent learning experiences that lead the individual learner to a higher level of knowledge and competency and/or the modification of behavior. Figure 4 shows a curriculum learn-flow which matches the ideas to support the cognitive learning process outlined above.

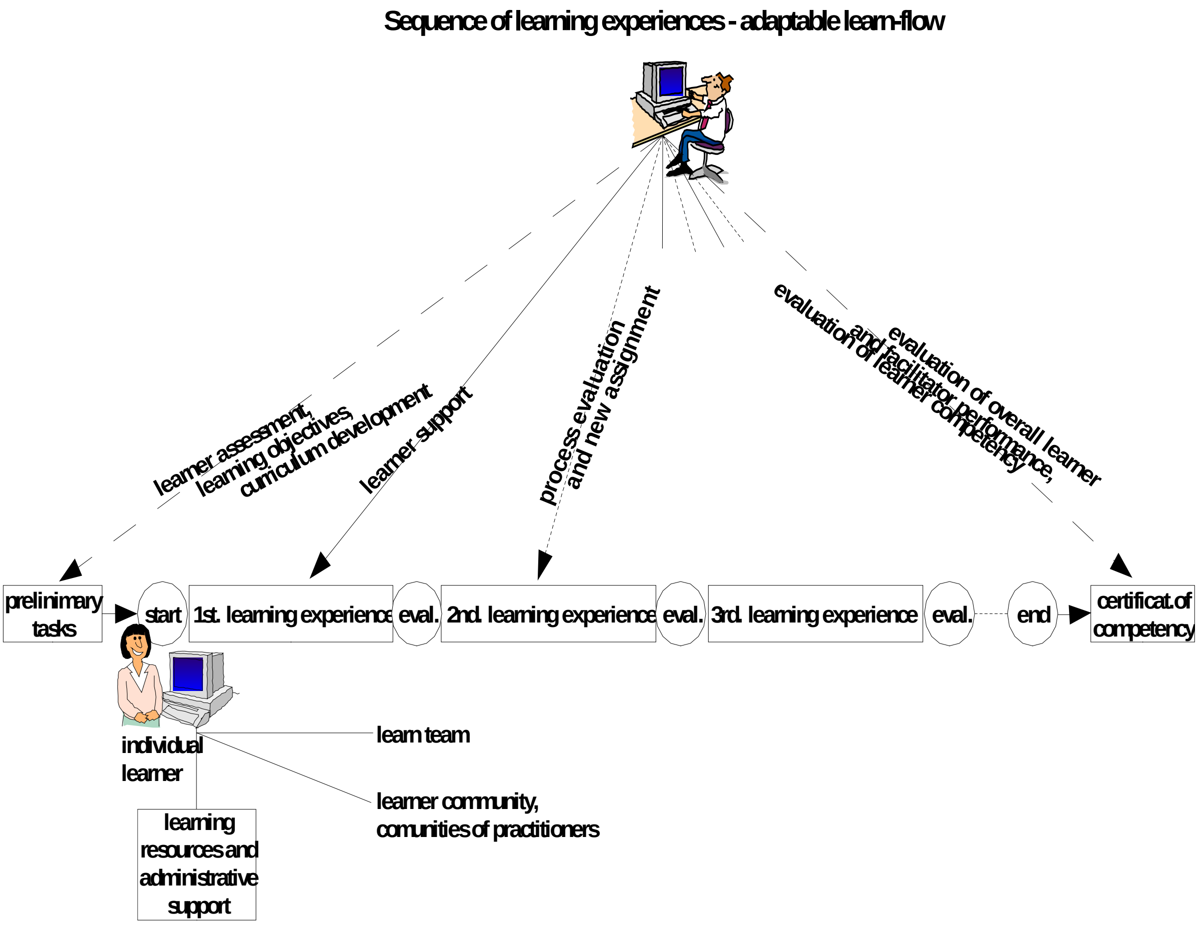

Figure 4 – Personalized curriculum as an adaptable learn-flow

After the learner's present knowledge and competency is assessed and his personal and situational preferences are evaluated, a curriculum is generated which ensures that the learner can meet his learning objectives. The curriculum consists of a number of subsequent learnings experiences which are based on RLOs. After the learner has completed a learning experience (worked through the materials presented by an RLO) his learning results and performance are assessed. If advisable, the learning facilitator revises/adapts the curriculum and selects a subsequent RLO. The curriculum ends with the certification of the type and level of competency attained.

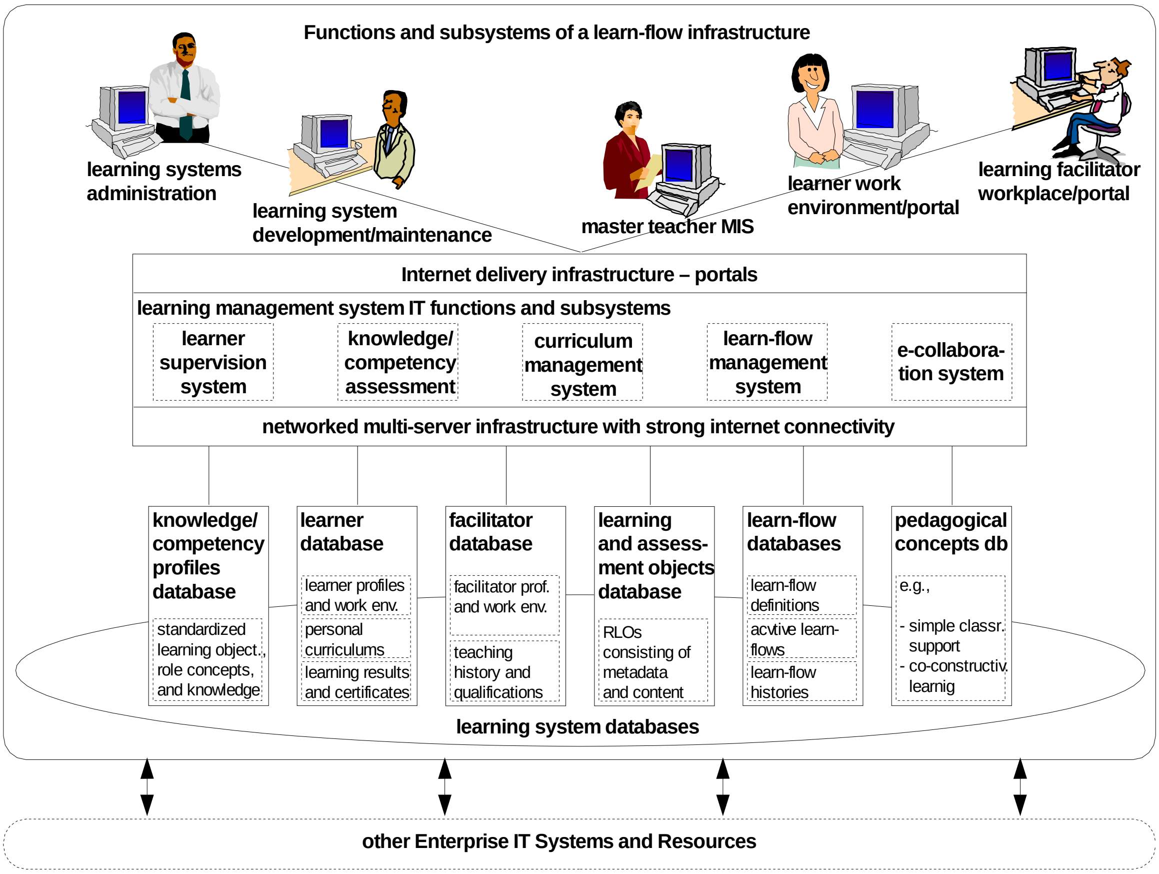

Figure 5 – Functions and subsystems of a learn-flow infrastructure

Instead of constructing RLOs which tend to become – from a technical perspective – always more complex, or waiting for different standardization bodies to join forces and to publish a complex but unifying e-learning standard, we suggest that at present it is advisable to place a standard/modified workflow engine at the core of an Internet-based e-learning system. A workflow engine with sufficient flexibility could be used to generate/manage personalized and adaptable learn-flows and could – during the course of an individual curriculum -- grant the learner access to subsequent learning experiences, RLOs and related resources/services. From a technical perspective, the structure of RLOs could be kept relatively simple and the RLOs could be relatively small and designed towards self-containment: Process logic, analysis of learner behavior etc. could be placed apart from RLOs in specialized engines.

Figure 5 outlines ICT functions and subsystems of a learn-flow-based LMS. The LMS functions and subsystems rest on a networked multi-server infrastructure with strong Internet connectivity and a number of databases. Aimed towards different types of users, Internet portal systems could be utilized to provide user type specific and customizable services.

The databases are use to collect data about a number of processes and entities:

- Knowledge and competency profiles database – The learner's readiness for the intended personalized learning process needs to be evaluated, therefore his present knowledge and competency has to be evaluated and compared to his learning objectives. Learning objectives have to be dissolved into standard role-based competencies and associated knowledge requirements (or patterns of behavior).
- Learner database – Individual learner profiles, privileges, and data of the learner's private work environment have to be stored. In addition the database contains personal curriculums, learning results, and credentials/certificates.
- Facilitator database – This database contains the private work environments of learning facilitators, data about their teaching history, and about their qualifications/certificates.
- Learning and assessment objects database – Learning objects including their metadata are stored in this db. An object -- or “unit of study” -- could be structured according to the EML/XML implementation concept proposed by Koper and contain metadata (title, subtitle, creator, description, copyright, study-load), roles (learner, staff), learning objectives, prerequisites, content (activity, environment – including knowledge object, announcement object, role information object etc.), method (activity structure, play, conditions). [Koper-2000, 31] The use of an other metadata model (e.g.; LOM) would result in different data structures and include type of object, author, owner, terms of distribution, format, pedagogical attributes (teaching or interaction style, grade level, mastery level, prerequisites, learning objectives). [IEEE-2002] Frequently the assessment of the learner's level of knowledge or competency is directly linked to RLOs which aim to generate them. Therefore, knowledge and competency generating RLOs and the respective testing modules are assigned to this database.
- Learn-flow databases – Workflow systems usually use databases for the general definition of workflows (workflow templates) and databases which contain actual instances or workflow histories. The system's learn-flow data is assigned to this database.

- Pedagogical concepts database – Definitions of pedagogical concepts are stored here and transformed into personalized learn-flow templates during the generation of individual curriculums. In the most simple case the pedagogical concept could be defined/described as the support of classroom teaching with consecutive lectures and the accompanying learning materials. The learn-flow management system would use this description to develop a simple learn-flow which presents learning materials and self-tests to individual course participants according to the course schedule.

The outlined LMS ICT functions and subsystems are to provide the following services:

- Learner supervision system – It is assumed that learning facilitators usually are in contact with their group of learners via the Internet. Therefore it is more difficult – as compared to a classroom or seminar setting – to evaluate the learners' behavior and to find out whether an individual learner might need support or encouragement. Learning systems at present use relatively crude mechanisms for behavior evaluation (e.g., number of times a learner has accessed electronic content, number of entries in discussion databases, number of e-mails to instructors or fellow learners). Given the sometimes high drop-out rates in Internet-based distance learning courses, a more sophisticated approach needs to be employed: The use of expert systems or neural networks could provide better learner supervision by constantly analyzing behavioral patterns and triggering learning facilitator intervention if necessary.
- Knowledge and competency assessment – The generation of efficient individualized learning processes requires, in general, assessment of the learner's actual knowledge and competency. Self-assessments and electronic tests might provide more insight into the learner's level of knowledge. A computer-based evaluation of competency levels can be a challenge and will have to involve human judgment regularly. After the learner has completed the learning process, the newly reached levels of knowledge and competency need to be assessed for the evaluation of process efficiency and learner certification.
- Curriculum management system – The efficiency of personalized learning processes relies on the analysis of the differential between the learner's present and planned levels of knowledge and competency. Based on the results of the competence assessment function and a comparison with individual learning objectives, the curriculum management system generates personalized curriculums.

- Learn-flow management system – Based on the generated curriculum and a suitable pedagogic concept – probably with revision agreed upon by the learning facilitator and the individual learner – a learn-flow is generated which guides the learner through a sequence of learning experiences. Taking into account the necessity of increasing the complexity of the learning material as well as changes in learner preferences and performance at a higher education level, learning facilitator intervention to change the course of events can be necessary or desirable. The learn-flow/workflow engine used in the LMS has to be sufficiently flexible to accommodate changes.
- E-collaboration system – The characteristics of learning goals and processes suitable for co-constructivist learning require intensive collaboration between learners, learn teams, and learning facilitators. Therefore, a sophisticated e-collaboration system (e.g., IBM/Lotus SameTime in combination with IBM/Lotus Notes/Domino) is needed. At the same time, e-collaboration systems can be employed to bring learners into contact with alumni and practitioners.
- Last but not least, a number of different user interfaces to a LMS have to be discussed. Given the complexity of the respective user tasks and the significant differences between them, separate (and customizable) interfaces (clients) are required for different types of users (e.g., learners, learning facilitators, LMS administrative staff, master teachers/managers).
- Learning system administration client – Learners have to be enrolled and assigned to learn teams or to learning facilitators, learner and facilitator system privileges have to be managed, database maintenance, the exchange of learning objects competency profiles or other administrative tasks have to be carried out.
- Learning system development and maintenance – Developers will work with specific multimedia, HTML/XML, or RLO authoring environments (MacroMedia AuthorWare, Flash/Fireworks, Adobe Premiere etc.). Specific development clients will usually not be required.
- Master teacher MIS – In large-scale e-learning environments – stretching across an extensive geographical area and sometime several time-zones -- managing, supervising, and coaching learning facilitators can be a complex task. The same is true for quality assurance and certification. A master teacher portal is suitable to support the master teacher responsibilities systematically and consistently.
- Learner work environment – The support of learners must be extended beyond the pure delivery of learning content and a (browser-based) learner client module should provide extensive support and information

functions (on-line/off-line) for learners regarding e.g., pursued competencies and learning objectives, curriculum structure and learning progress, time planning for private and team learning events, learn team/facilitator related net-presence indicators, e-library access, private electronic bookshelf for long-term access to completed/annotated learning materials. [Finke-2000, 239]

- Learning facilitator work environment – Learning facilitators usually are adjunct faculty. They might accept responsibility only for a limited set of learn teams or for a limited period of time. With regard to quality assurance and consistency of learning services a well-designed work environment for learning facilitators is necessary. Important functions are learner behavior analysis and progress control, functions for setting up and revising personalized curriculums, functions for knowledge and competence assessment, learner contact management, time and resources management etc.. [Finke-2000, 245] Some of these functions could be supported by expert systems (e.g., development/revision of personalized curriculums).
- The benefits of ICT support for the learning systems functions outlined above might be obvious and in some cases indispensable. At the same time, standardization of learner clients or learning facilitator work environments (or other functions and components of LMSs) might be somewhere in the distant future at best. So there is clearly a chasm between the idea to build LMSs and RLOs on the basis of existing/emerging standards and the urgent need of educational services providers to offer sophisticated educational services to a fast increasing number of learners – based on feature-rich but non-standard LMSs. In this dilemma, one of the solutions could be to use small and relatively simple learning objects (purely based on standard Internet technology) together with one of the relevant (with regard to industry segment, market share etc.) metadata concepts. The RLOs then have to be managed within a database environment and need to be connected to a standard workflow system or a simple, workflow-oriented LMS. One of the benefits of such a solution would be the reduced cost of the – inevitable – revision and adaptation of the LMSs and RLOs to future technical developments and user/learner needs.

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