Towards active learning management systems

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The paper describes new trends in learning and ways to support them using information technology. It makes a distinction between active and passive learning management systems (LMS). It defines passive LMS as those whose learning plans are clearly defined by instructors, and where students follow these learning plans precisely. Active LMS on the other hand can adapt to learner defined goals by using learning plans adapted to learner goals. A number of services must be provided by active LMS. These include services to define learning plans and actively construct workspaces. Services to manage such workspaces are also needed. Software agents are proposed as one way to provide such services and some such agents are described.

Keywords: Learning spaces, learning objects, software agents, constructivist learning

Introduction

Most learning management systems (LMS), such as Blackboard or WebCT, are passive in the sense that they require instructional material to be set up by instructors. Learners access these materials and use them in ways specified by the instructors. Such systems generally support instructor directed classroom learning. However, such passive systems have limitations in the current educational trends. These trends are that:

- Learning now takes place in many environments other than formal education at teaching institutions. Learners can also be students in individual institutions or they can be in industry.
- Learners now come with different motivations and have different learning objectives (Biggs, 2000). There are learners who are specifically seeking training in some area, and those who have the motivation to become experts in their area. Different methods of instruction are often appropriate for these different classes of student.
- There is more emphasis on constructivist learning within a self defined or at least flexible context.
- There is greater emphasis on groups in large classes. Such groups often require more guidance (Biggs, 2000) whereas growing classes and increased internationalisation and class size make such guidance more difficult to provide on an intensive and personal face to face basis.

These trends call for new methods of instruction (Koper, 2000) and new ways to use technologies to support these methods. In summary, the general trend is to more personalised learning where learners define their learning plans and the LMS constructs and supports the learning process. A LMS system must adapt to these methods and provide personalised proactive support to learners. We call this kind of LMS an active LMS. An active learning management system assists learners to develop and follow a learning plan to satisfy their learning objective. The learning plan includes a number of learning steps to be followed to reach the learning goal. The active LMS should provide assistance to progress through these steps. An active LMS goes beyond simply allowing students to learn at their own pace but actually decides what to learn. This contrasts with current learning management systems, which present materials and require learners themselves to use them in prespecified ways.

Ways of supporting active learning environments using information technology have evolved over time. One way to view such evolution is through the three levels shown in Figure 1. Level 1 is the traditional learning management system (LMS) that contains context information and allows students feedback through frequently asked questions. Often these questions either relate to administrative questions to simple questions about subject content. The next level is level 2 where more intense interaction is supported. Such interaction can be used to build knowledge rather than simply exchange simple questions. A number of possibilities exist here. One is discussion groups moderated by instructors within the subject context. Another is interactions within a student group. Both levels 1 and 2 still follow a well defined goal and assessment requirements. The next level, level 3, goes further. It begins to emphasise self directed learning where learners define specific learning needs. The learners build on their knowledge through a continuous and guided process of identifying learning goals, discussing and trying ideas by themselves or through participation in groups, and recording outcomes in their learning outputs. The goal of the research described here is to facilitate ways in which learners can be guided towards achieving their learning goals by using active components rather than instructors. These active components will set up personalised workspaces for students and provide contacts to individuals or groups for guidance or interaction.

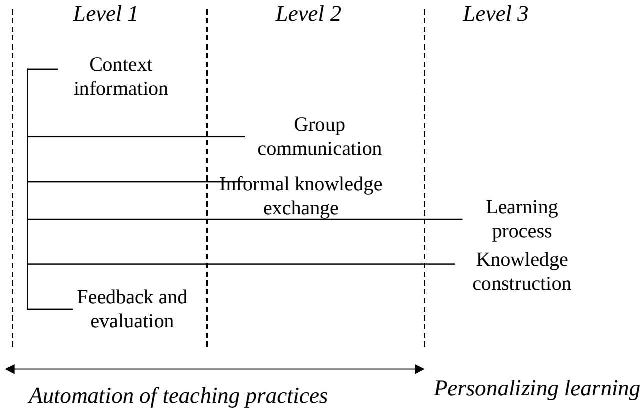


Figure 1: Spectrum of support systems

One important goal of an active LMS must provide a way to define learning goals. An active LMS must assist learners to setup specialised learning spaces, and to manage these learning spaces. A formal structure of defining learning plans is needed so that it can be used to construct and manage learning environments. The learning environment becomes a workspace constructed out of available services and supported by agents as also suggested by Kunz (2004). We begin by first defining some general needs of level 3 systems. We then suggest that such systems cannot be simply used by learners and suggest that software agents be used to assist learners to set up and manage such learning plans.

Characteristics of active systems

One way to define active systems is to use the idea of service (Hiltz & Turoff, 2002) to describe support provided for learners. The major services provided by Level 1 and 2 systems include content management, discussion forums, and support for submissions and feedback. Additional services are needed by Level 3 systems to support personalised learning. This paper identifies services for Level 3 systems by analysing the educational requirements of Level 3 systems. The most important requirement is to provide an environment conducive to constructivist learning. Suggestions here include setting thick problems and learning within a group social context. Such problems go beyond being ill-structured but must present situations as one would find them in the real world (Petraglia, 1998). They must also exhibit complexity that requires choices to be made and thus support learning in a social context. Jonassen (2002) stresses the need for group based learning using constructivist approaches within a context and also notes (Jonassen, 1999) that there must be supporting culture for group learning in the teaching institution. Working in teams provides the opportunity to discuss and try ideas to build on their knowledge through a continuous and guided process of identifying learning goals, and record outcomes in their learning outputs. The role of instructors changes more to that of a guide with students being apprentices. Such processes can also emphasise competency based learning (Hezemans & Ritzen, 2002), which is also becoming more important in practical environments. Learning objects can play an important role in Level 3 systems. This role differs from learning objects for Level 1 and 2 systems. Learning objects in Level 1 and 2 systems can be fixed, whereas those in Level 3 systems must be more open or generic so they can be combined with other objects to build customised learning plans.

The next question is what kind of services are needed to support such environments.

Required services

One important requirement is support for teamwork and the tools made available to teams, while providing options to learners to join such teams. Jonassen and Rohere-Murphy (1999) also suggest the following requirements to encourage constructivist learning based on activity theory. In summary the requirements are:

- It should be possible to easily create workspaces for teams and to assign responsibilities to team members,
- Such workspaces should include conversational tools to support interactivity,
- There should be support for reflection to provide insight into learning,
- There should be a context and that includes thick problems that exhibit complexity and choice,
- It should be possible to access subject material and information resources relevant to the study goal,
- There should be related cases provided as examples that are easily accessible,
- There should be cognitive tools to help structure thinking and knowledge building, Includes representation (visualisation), dynamic modeling, semantic organisation, interpretation of information as well as help using these tools.

At a more detailed level questions arise on what interactions are needed? These include prompts to represent apprenticeship elements and check lists. Support systems must allow learners to vary the problem. Workspaces should then allow group members to clearly define roles, such as for example the teacher being the legitimator of expertise rather than director of activities.

Learning objects for flexibility

Learning objects have been proposed in answer to the need to share materials across learning environments and can provide a basis for constructing level 3 systems. Learning objects are still a concept that needs some adjustment to a suitable implementation. Most standards such as the Dublin core [http://www.dublincore.org] and the Learning Technology Standards of the IEEE [http://ltsc.ieee.org] usually define a learning object as an integrated set of subject material together with its supporting services. Our approach is to have a lower level of granularity. For example, it should be possible to include the same problem context can be used in different learning activities. This agrees with some other designers of systems based on learning objects. Fisher (2001) suggests the need to define object classes and metadata to describe their combination. Koper (2000) on the other hand defines units of study composed from subject and learning models. We closely follow Koper's work but suggest that learning objects must be open so that they can be combined in flexible ways to construct units of learning. We suggest that such units of learning can be constructed and managed by software agents.

Support for learner driven systems

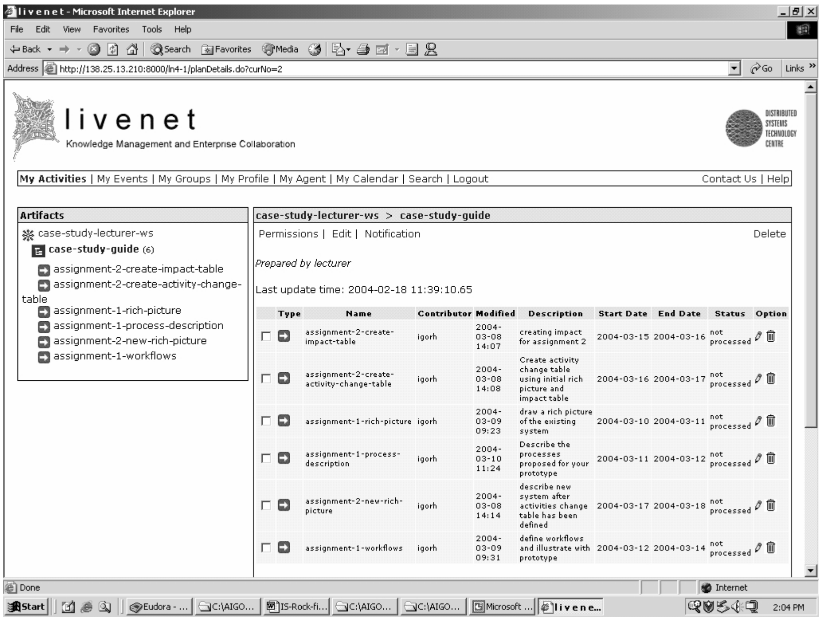
We now describe some the tools and services needed to support Level 3 systems. We are using a workspace system and are developing prototype generic software agents to see how agents can assist learning. Students can define their private workspaces and interact between themselves and the instructor. Workspaces can be used to provide services needed for supporting personalised approaches. The instructor or students themselves can also provide cognitive tools that help students in the system design and provides suggestions of how students can proceed in their case study. These services emphasise the ability to deal with thick problems that provide students with the choices to suit their learning plan. Our first goal was to provide support for collaboration within teams.

Group learning support

Working with others in teams both increases the breadth of knowledge acquired, its relevance, as well as evaluations of the application of new knowledge in a problem area. Group activities, however, are only effective if they follow processes that encourage idea generation and evaluation, discussion and conflict resolution in timely ways following well defined learning steps. Group learning support should provide the services to overcome group problems. These problems include making joint decisions, reluctance to deal with conflict, guidance on learning steps**,** and leaving things till last. Our services thus first concentrate on developing learning plans and facilitating group activities. The steps followed to set up and control such plans for learner groups are:

Step 1 - The instructor sets up broad goals and a suggested learning plan. The plan is created by instructors, who use the planning service. The plan is shown in Figure 2. It uses our LiveNet system. The plan is made up of a number of learning activities, including their start and end dates, together with supporting materials relevant to each learning activity.

Step 2 - The student group then creates their own workspace that copies this initial plan into their workspace. They can then adjust this plan to their needs using the plan services.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assignment-2-create-activity-change-table
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assignment-1-process-description
assignment-2-new-rich-picture
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□	➡	assignment-2-create-impact-table	igorh	2004-03-08 14:07	creating impact for assignment 2	2004-03-15	2004-03-16	not processed	✎ 🗑
□	➡	assignment-2-create-activity-change-table	igorh	2004-03-08 14:08	Create activity change table using initial rich picture and impact table	2004-03-16	2004-03-17	not processed	✎ 🗑
□	➡	assignment-1-rich-picture	igorh	2004-03-09 09:23	draw a rich picture of the existing system	2004-03-10	2004-03-11	not processed	✎ 🗑
□	➡	assignment-1-process-description	igorh	2004-03-10 11:24	Describe the processes proposed for your prototype	2004-03-11	2004-03-12	not processed	✎ 🗑
□	➡	assignment-2-new-rich-picture	igorh	2004-03-08 14:14	describe new system after activities change table has been defined	2004-03-17	2004-03-18	not processed	✎ 🗑
□	➡	assignment-1-workflows	igorh	2004-03-09 09:31	define workflows and illustrate with prototype	2004-03-12	2004-03-14	not processed	✎ 🗑

Figure 2: Developing the high level plan

Step 3 - The system provides a service to initiate each learning activity at its start date making suggestions for progress, including relevant examples. A new workspace such as that shown in Figure 3 is then created automatically for each activity. This workspace includes cognitive tools as well as sample solutions,

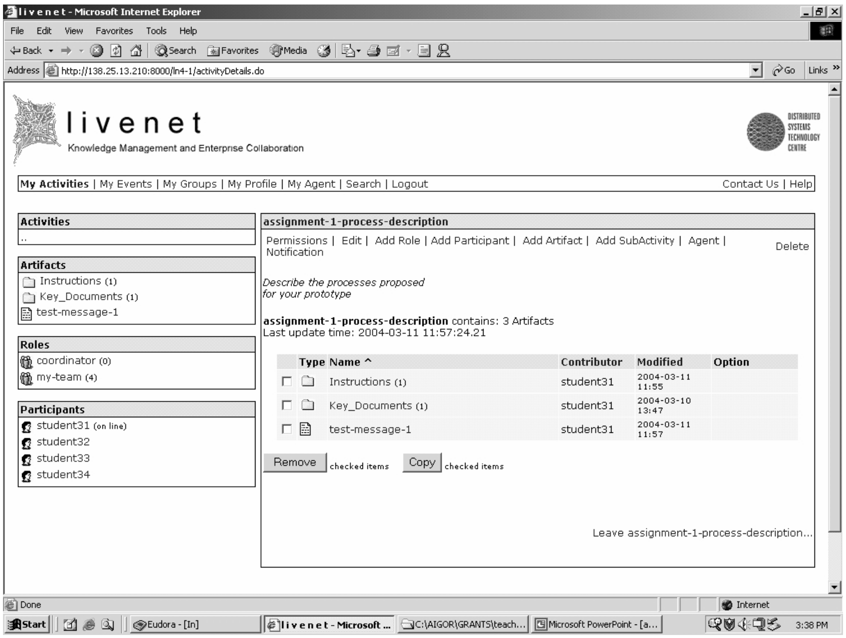
Step 4 – Here students interact with each other in the activity workspace and are monitored to identify progress and notified when actions are needed.

Initial trials have identified issues that must be resolved to improve such support. A presentation that shows all learning activities on the one workspace rather than individual workspaces is preferred. Another are services for student interaction with the instructor, who can then present comments in the context of the learning activity. This may require keeping track of all actions taken by the students that allow the instructor help students reflect on these actions. Still a third is the question whether services that monitor progress are to report major deviations to the instructor or to suggest ways for the group to improve their collaboration. Such services can also assist in providing peer pressure on individuals not participating in groups by regular requests for contribution and if necessary making reports to the instructor.

The second major issue is that such services need to actively assist learners to carry out their learning plans. Our proposal is to use software agents for this purpose and to define the capabilities needed by such agents.

What are agents and what services can they provide?

Software agents perceive their environment and initiate action in these environments. In the case of learning environments, the agents sense the state of each task, the activities in each task. It then takes actions to facilitate the completion of the learning activity.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Activities

..

Artifacts

Instructions (1)
Key_Documents (1)
test-message-1

Roles

coordinator (0)
my-team (4)

Participants

student31 (on line)
student32
student33
student34

assignment-1-process-description

*Describe the processes proposed
for your prototype*

assignment-1-process-description contains: 3 Artifacts
Last update time: 2004-03-11 11:57:24.21

	Type	Name ^	Contributor	Modified	Option
□		Instructions (1)	student31	2004-03-11 11:55	
□		Key_Documents (1)	student31	2004-03-10 13:47	
□		test-message-1	student31	2004-03-11 11:57	

Remove checked items Copy checked items

Figure 3: A workspace created for a learning activity

Two kinds of agents are considered. One is where agents actually play a role. This is exemplified by the work of Baylor (2003) where agents that took the roles of teacher and expert were provided for students. Here the agents interact with learners. They can either be requested by learners to provide assistance. Alternatively, they can observe what is happening and offer advice.

The other approach is where agents sense activities and facilitate the learning process. These agents perceive the progress of learning activities and provide prompts to assist learners. In that case the agents can assist users to set up workspaces and to manage these workspaces. Two kinds of agents are proposed here. One is to manage the learning plan and the other to manage the learning activities.

The learning plan agent identifies times to commence activities. It perceives the state of each learning task and suggests times to start the next. The learning activity agent monitors the progress of each activity. It perceives changes to key documents and interactions between users. The agents coordinate their work. Figure 4 illustrates the agents identified and the multi-agent structure. Here there is a unit of learning using an agent that follows a plan that includes the completion of a number learning activities. The agent goals here are now different and center on creating and monitoring learning activities. The unit of learning agent delegates work to learning activities. To do this, it creates a workspace for each learning activity and an agent for that activity. The unit of learning agent monitors progress on the learning activity task.

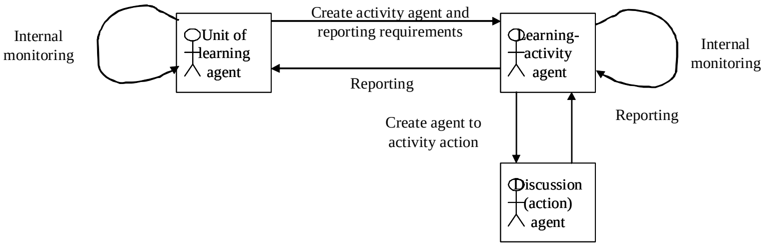
Internal monitoring
Unit of learning agent
Create activity agent and reporting requirements
Reporting
Learning-activity agent
Internal monitoring
Create agent to activity action
Reporting
Discussion (action) agent

Figure 4: Architecture of selected agents

The work so far has illustrated the infrastructure for generic software agents. The detailed definition of the agents can be found elsewhere (Hawryszkiewycz & Lin, 2003). The two workspaces shown in Figures 2 and 3 could, in the generic sense, represent many work situations or learning environments; for example, the plan could be a software engineering process. The agent for the process then generates workspaces for the individual software engineering tasks, allocates people to them, enters the relevant documents and notifies participants to commence their work.

Future work: Creating learning plans and environments

The agents that we have built so far mainly facilitate the learning plan. The next step is to provide agents that create the customised learning plan. To do this it is necessary to provide:

- a set of generic objects that can be used to construct customised learning plans,
- a way to define learning plans, and
- software agents to construct customised learning places.

Defining the learning goal

The first step is to define the learning goal. The metadata definition is used to construct units of learning from generic components.

Learning-unit-name: <@work-unit-name='my-objective'>….choose a name for the learning unit
Learning-unit-goal: <@goal-type='How to design collaborative systems">
Learning-unit-output: *{<@output-type=system design>}
Learning-policy:{<@reporting criteria>, <@process-type>}
Information sources:*(<@type>: <@name>)
Learning-environment:
    {+Location:<@organizational-unit='university'>
    Learning-context:<@description='course'>
    People: +{<@role>: <@person-name> }

The @ symbol is used here to indicate a choice to be made, usually with the assistance of the learner. This definition now becomes a goal for choosing and composing a unit of learning from a set of generic learning objects.

Providing generic objects

The structure of the unit of learning is shown in Figure 5. It shows the classes of objects that make up a unit of learning and follows the same structural description as Koper but allows learning objects workspaces are created. To do this it is necessary to make a number of changes from Koper's ELM model and hence have named our model as an Active Learning Process Model (ALPM). The changes are mainly in parameters that of necessity must be left open to choice rather than defining specific objects. This will enable agents to choose compose alternate learning places from the generic learning objects.

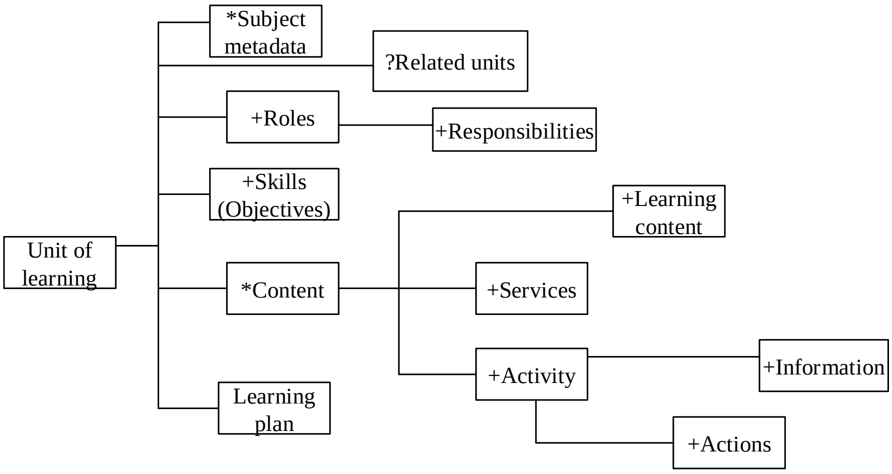

Figure 5: Defining learning models

A unit of learning can be made up from any of its components. We now describe some such units in broad form to give an idea of how units of learning are composed. The symbols used closely correspond to those of Koper and are:

? optional
+ one or more instances
{} a set of elements
@ open parameter
<type>:<name> a type followed by individual instance name

* zero or more instances
- select one of
<> type of object

Given the earlier definition of our learning goal, the software agent must find a unit of learning called "How to design collaborative systems". This unit of learning can use a number of different plans, as for example, a case study learning plan.

Unit of learning
Unit of learning is a composite learning object that may correspond to a university subject or an update seminar. It is a complex structure that contains meta-data and other components that describe what, why and how the subject can be studied.

```
-Learning-unit-goal(design collaborative system)
-Learning-unit-description (follow case study in a group))
+Roles: {<@type>:<@name>} …. Usually added when activities selected
Learning-unit-process-type: -(group work, individual study …) .. requires choice
content:
        {+services: <@name> … usually chosen when learning activities are selected
         +learning-content{:{<@information>:<@type >,< @output-artifact>: <@type>}}
Learning-evaluation: - {formal, informal}
Learning-plan-type: -<@plan-type>
Learning-environment:
         {+Location:<@organizational-unit>
        Learning-policy:<@description>
        People: +{<@role>: <@person-name> }
```

The chosen unit of learning identifies the chosen way of learning as the learning unit process type. This will identify the type of learning plan that is needed by matching it to the learning plan goal in the learning plan object.

Learning plans

```
Learning-plan-goal: <@plan-goal> …………..for example, group learning
Learning-plan-objective: <@objective-description>
Plan-process-type: -(predefined, emergent )
+{Step-no, Activity-goal<@activity-goal}
  Activity-type:- {well-defined, creative}
+Learning-content:
+Activity-output:{<@activity-output-type>:<@name>};
+Activity-input:{<@activity-input-type>:<@name>};
current-status:}
```

The learning plan has a number of steps each of which results in a learning activity. Each step defines a learning activity and the inputs and outputs needed by that activity. The agent uses the activity goal to select the most appropriate activity. An example of a learning activity definition follows.

Learning activity
Activity is a formal description of a learning step with a clearly defined goal. It describes the actions to be performed in a learning step as well as the environment and resources that may be needed to achieve the goal of the activity.

```
Activity-goal: (@activity-goal)
-Activity-type (@activity-type) ------- creative, predefined
+Service-type-options: (@service-type) …. Retrieval, interaction
```

-Learning-content:
+Activity-output: :{<@activity-output-type>:<@name>};
+Activity-input:{<@activity-input-type>:<@name>};
*Review criteria: (review,…)
*Cognitive tools:
+Action-goal: (@action-goal) …… for example, joint edit

The learning activity includes the specification of the actions and services needed by the activity. These are used by the agents to select the most appropriate instantiations of such actions and services.

Actions
Actions are concrete initiatives to be performed as a part of wider activity, in order to achieve the activity objective. The actions usually refer to system services, like creating a chat room or group assignment communication space, or doing a quiz. Agent matches action objective to that stated in the activity definition.

Action-name: Carry out questionnaire;
Action-objective: Assess knowledge.
Action-type: +{on-line questionnaire}
+Service-types: web
+Roles: observer: observes student inputs.

Constructing the learning spaces

The unit of learning is now built by the individual agents associated with each learning object. The process is briefly illustrated in Figure 6. Here:

- The agent locates a unit of learning from the definition of the learning goal,
- The agent finds a plan that matches the selected unit of learning,
- The agent then uses the plan to construct learning activities by matching the step objectives in the learning plan to activity objectives.
- The activity actions are then matched to services and added to the workspace.

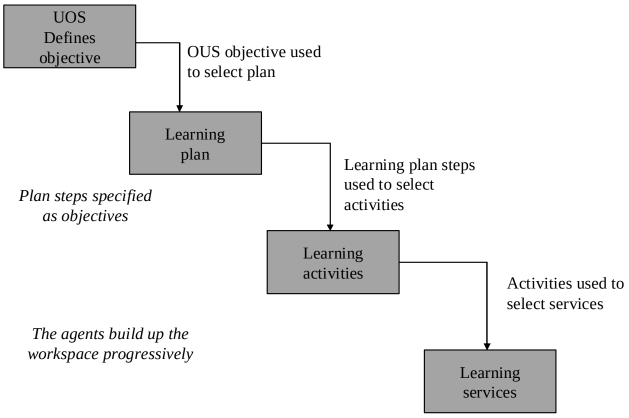
UOS Defines objective
OUS objective used to select plan
Learning plan
Learning plan steps used to select activities
Plan steps specified as objectives
Learning activities
Activities used to select services
The agents build up the workspace progressively
Learning services

Figure 6: Constructing learning workspaces

The agents add to the workspace as the process takes place. They also construct the roles and learning content during the construction process. They must ensure consistency between the activities.

Summary

This paper outlined the need for greater flexibility in learning systems. It suggested a trend to systems that provide greater learning flexibility where learners can select what they want to learn and how they want to learn it. The paper suggested that such a trend can be best met by adopting learning methods that emphasise the constructivist approach within a context. The paper outlined the limitations of current learning management systems in supporting this approach and identified the kind of services that systems should provide. It concentrated on services that support group learning and suggested that such services be enhanced with software agents. The agents should have the capabilities needed both to monitor and facilitate progress through a learning plan, and support the evolution of learning plans. The paper then proposed that such support should include the ability to create customized support systems for personalized goals and outlined a way of defining such goals and constructing support systems.

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