Trails of Digital and Non-Digital LOs

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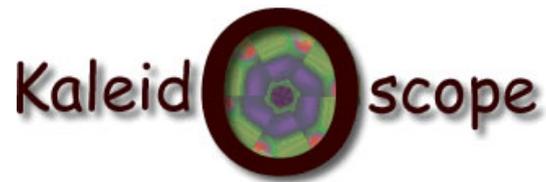
future of learning with digital technologies

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Technical report summarising integration of digital and non-digital LOs.

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Summary

This document investigates scenarios where learners navigate (follow trails) through
environments containing digital and non-digital learning objects, considers some user
requirements of systems designed to support the use of trails and presents a possible classification of different
types of trail to form an ontology of trails. Separate
sections include investigations of trails in different pedagogical approaches, trails in
mobile learning scenarios, trails in computer conferencing and the provision of adaptive navigation support. A
case study of using the IMS-LD to work with trails is also included.

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TRAILS

The World-Wide-Web has had a major impact on enabling large, diverse and geographically distributed communities of learners to access Technology Enhanced Learning. Systems combining technological learning tools with personalisation that caters for individual styles and learning preferences have the potential to radically alter the landscape of learning. A recent development has been in the use of learning objects (LOs) – cohesive pieces of learning material that are usually stored in a repository, allowing teachers and learners to search for LOs of interest to them. Learners engage with LOs in the form of trails – time-ordered sequences of LOs.

Examples of LO trails are:

(i)   a school-child navigating through course materials,

(ii)   a learner navigating through the literature on a subject, or

(iii)   a visitor navigating through a museum.

By following and creating trails, the learner navigates through a space of LOs creating a personal trail that can be evaluated and accessed in a structured manner. These directly observable LO trails are related to learners' non-observable cognitive trails.

Trails are the subject of the *Personalised and Collaborative Trails of Digital and Non-Digital Learning Objects* project (TRAILS for short). TRAILS is a one-year Jointly Executed Integrating Research Project within the Kaleidoscope Network of Excellence, an IST project funded under EU FP6. At the core of the programme is the view that trails can provide structure to learners' information space and thus can assist them in achieving their objectives. TRAILS brings together experts from computer, social and cognitive sciences in order to:

- generate a framework for describing, classifying and understanding trails of LOs;
- study the pedagogical and cognitive aspects of personalised trails;
- investigate the types of individual need (personalised, individualised, collaborative, context dependent and content dependent) which learners have in terms of trails;
- evaluate and assess methods, which cater for learner needs;
- produce a schema for representing these learner needs in a specific user profile;
- produce a schema for integrating learner needs with appropriate LO metadata;
- design a system for mapping the patterns of trails created by learners and for producing a training needs analysis for targeting future learner experiences;
- investigate different types of LOs and how they may form trails;
- specify the requirements which trail-support places on e-Learning systems;
- work towards a standard for LOs in trails which is compatible with current standards.

Executive Summary

This document is the first deliverable within workpackage 2 of TRAILS. Within TRAILS, workpackage 2 is dedicated to pedagogical aspects of trails. The objectives of work package 2 are:

- To investigate scenarios where learners navigate through digital and non-digital learning objects in the trails they follow.
- To investigate related user requirements on a system to support the use of 'mixed trails' in learning.
- To study a framework and ontology for trails of learning objects which is compatible with Semantic Web technologies.

According to the workpackage description this deliverable 'describes the challenges which mixed (= a combination of digital and non-digital) trails present to the learner in terms of navigation, revisiting and refinement. It also describes a possible ontology for trails and reports on standardisation issues'.

This deliverable will be supplemented by a study of various scenarios of learners navigating through mixed trails containing digital and non-digital learning objects and the roles these trails fulfil, which will be delivered by December 2004.

This deliverable achieves the several objectives laid out in the project proposal. First, it describes two methods by which digital and non-digital learning objects can be integrated. This is done in Chapter 4, which examines trails in mobile learning. The first method of integration is by means of digital placeholders. By a digital placeholder we mean a digital object that accompanies the visit to the non-digital learning object, e.g. the audio tour accompanying a museum visit. The second way to integrate digital and non-digital learning objects is by means of the digital results that learners create in reaction to non-digital objects. An example is the notes that a learner makes regarding a particular painting. These two means, digital placeholders and digital result objects can be combined within a trail, e.g. in the case of a learner who reads questions regarding a particular painting (= digital placeholder) and answers these questions, thereby creating digital result objects.

The second objective of this deliverable is to describe the challenges which trails present to learners in terms of navigation, revisiting and refinement.
Two types of navigation issues have been discussed. The first challenge is to describe the different trails that learners follow in different pedagogical approaches in such a way that it

becomes possible to plan these trails. This is done in Chapter 2 for several pedagogical approaches, by describing for each approach the several stages that learners pass through, the typical learning objects that learners engage with, and the metadata that is necessary in describing the learning objects and the trail itself. Chapter 6 elaborates the process for one specific scenario, in a more advanced way. The description of the scenario in this chapter is based on IMS Learning Design, and thereby provides an indication of how the scenario can be to technically implemented using an XML-based schema.

The second navigational issue is how to create navigational aids for learners in following a trail. Chapter 3 presents a navigational aid in the form of a navigational map. Learners are supported in choosing their trail by a map that shows those learning objects that the learner has passed and those learning objects that still need to be passed to attain a certain level of achievement, or other learning objects that are of interest to the learner.

A navigational map can also be an aid in revisiting trails. Revisiting is especially relevant in the case of trails of objects that have been created by the learner during the learning process. These include 'results' of visiting learning objects and discussion messages created by the learner. Chapter 5 shows ways of labelling discussion trails in such a way that the learner benefits from revisiting the trail and reflecting upon it.

Refinement of trails is discussed in Chapter 3, where the process of learners working with learning objects leads to updating of the personal profile and updating of the navigational map. The basis for both refinement and revisiting trails is data collection. Several methods of collecting data on trails are discussed in Chapter 7.

The third objective is to describe a possible ontology for trails and reports on standardisation issues. The taxonomy presented in Chapter 8 makes a promising start in achieving this objective. In the taxonomy, a first distinction is made between trails proper and graphs, which may contain several trails. Trails are linear sequences of learning objects. Graphs contain possible trails, and can be divided into learning environments and mind maps according to the type of links between learning objects. Trails are further classified according to the majority type of learning object within the trail. Here a distinction is made between learning object trails, discussion trails and result trails.

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1   Introduction

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1.1   Method

The main objective of the Kaleidoscope network is to integrate and build upon existing research on technology enhanced learning that is carried out all over Europe. Therefore the work for workpackage 2 of TRAILS has been divided into two parts, the first aiming at bringing existing work together and the second part aiming at integration. In the first part, the partners of workpackage 2 each provided descriptions of their own research relevant to TRAILS. The descriptions focus on two questions:

1.   What kind of trails do occur in education?
2.   How can learners be supported in working with trails?

In the second part of the work, a taxonomy of trails was set up. Setting up the taxonomy required several integrating activities. First, it was necessary to classify the different kinds of trails that had been described in the work provided by the partners. Second, it was necessary to arrive at a common language to talk about these different types of trails. After these matters had been settled, a classification was set up.

1.2   Summary of results

This section presents a short overview of each chapter of this document.

Chapter 2, 'Trails in various pedagogical approaches', examines trails that occur in various pedagogical approaches, namely problem-based learning, inquiry learning, discovery learning, cognitive apprenticeship and classroom learning. Each pedagogical approach is characterized by a unique series of stages that the learners pass through. In each stage, learning objects (LOs) may or may not be present. In this approach the emphasis is on the trail that the learners follow through the stages. This is, in general, partly a trail through LOs and partly a trail through discussions and collaborative action.

In Chapter 3, 'Adaptive navigation support', the focus is on personalisation of and navigation through non-linear computer-based learning materials. This chapter is about learning designs where learners can decide which material they will visit and in what order. Learners thus

define their own trails. They are supported in doing so by a map, which shows those LOs that the learner has passed and those LOs that the learner has not yet passed, but that the learner needs to pass to attain a certain level of achievement, or other LOs that are of interest to the learner.

Chapter 4 examines trails in mobile learning. It describes several experiments using mobile technology to support museum visits. Mobile devices with additional digital information, which often includes but goes beyond an audio tour, accompany the visit to the usually non-digital museum objects. In some cases, learners have the possibility to make digital notes.

Chapter 5 is called 'Trails in computer conferencing'. It describes a method of analysing contributions to computer conferences, so that discussion participant can reflect on their contributions afterwards. This chapter shows a graphical technique that provides an overview of the discussion by displaying the contributions that individuals make to the various threads of the discussion.

The approach in Chapter 6, 'Working with trails: a collaborative case study, using the IMS-LD approach' is similar to the approach of Chapter 2. In Chapter 6, the stages that learners pass through in one specific pedagogical scenario are central. Chapter 6 is more advanced than Chapter 2 in that there is attention to roles of learners, and a method for supporting the learners, using IMS Learning Design, is sketched.

Chapter 7 focuses on data collection. Data collection is very important in working with trails. Chapter 7 explains that data collection can be used both in individual and in collaborative situations or actions to help learners in tracking/understanding the followed trail, in building maps and in improving the learning strategies. Chapter 7 goes into the type of data that can be collected, the format that collections have and the devices that are used in collecting the data.

On the basis of the preceding chapters, a provisional taxonomy of trails is defined, which is described in Chapter 8. A first distinction is made between trails proper and graphs, which may contain several trails. Trails are linear sequences of LOs. Graphs contain possible trails, and can be divided into learning environments and mind maps depending on the type of links between LOs. Trails can be further classified according to the majority type of LO within the trail. Here a distinction is made between LO trails, discussion trails and result trails.

1.3 Trails in education

In the introduction trails were defined as 'time-ordered sequences of LOs'. The chapters of this deliverable show that within this broad definition, several types of trails can be distinguished and several views on trails can be held. This section describes the several types of educational trail.

Emphasis can be placed on the sequence of LOs, and stages that can be distinguished within this sequence. This is the focus of Chapters 2 and 6. In these chapters, trails are seen as a designed route through a learning environment in which the stages of the route are clearly defined, sometimes including a time limit to one or more stages. The exact LOs to be visited within each stage are usually not precisely defined. The emphasis is on designing a learning environment beforehand, rather than on analysing trails afterwards.

Personalisation is the focus when the trail is seen as a route whose exact path depends on characteristics of the learner. This view of trails is advanced in Chapter 3. Chapter 3 describes how LOs in a grammar course are classified according to topic and difficulty or level. Learners take a pre-test and based on the pre-test routes are presented to the learner that match their current level of achievement and personal interest in topics.

Creating different routes for learners with different roles, in which the route is based upon learner characteristics, is closely related to personalisation. This is described in Chapter 6. With some stages a distinction is made between different roles, and each role has its own activities to be carried out, and thus different LOs to be visited or to be created. For example, within one discussion the task of most group members may be to advance arguments, whereas the person with the role of reporter has to take notes.

Within the above approaches, a trail is seen mainly as a route that is designed to be followed by learners. A different view is of a trail as a route that is created by the learner. This is the focus of Chapters 4 and 5. In its extreme form, this means that the learners create all LOs and trails; there are no LOs in the learning environment when the learners start. This is the case in a discussion, which is the topic of Chapter 5. Another example is trails through non-digital LOs. In this case, the digital trail does not exist when the learner enters the learning environment, but is created by the learner by recording the object into a digital format or by reacting to the non-digital object in some way. Chapter 4 presents the example of a museum visit, in which the learner creates a trail by making pictures of the objects and by making notes.

From the above, it becomes clear that not only are trails very different, the LOs involved are also different. One obvious distinction is that between pre-existing LOs and objects that are created by the learner, for example in a discussion or as a reaction to a LO.

1.4 How to support learners in working with trails

Learners engage with trails in several ways. The description above deals mostly with following trails. Learners follow trails, for example trails that have been authored by others, or by creating their own LOs, e.g. in a discussion. However, there are other things that users can do with trails. They can reflect on their own trail afterwards, e.g. to see how they can improve their performance. They may then want to revisit the trail, or to follow a similar, but slightly different trail, e.g. a trails that is just a bit more difficult.

These ways of engaging with trails must be supported by various types of technology. With respect to following a designed trail the LOs must be present in the learning environment, but also the route to be followed must be somehow defined. Chapter 6 describes how this can be done with trails through successive stages. With the use of IMS Learning Design, the learning environment is described in a formal way. The route to be followed by the learners is divided into several acts, which are in turn split up into several activities. Each activity is associated with specific roles, making differentiated routes between learners possible. To control the flow of activities, 'properties' are added that indicate whether a specific activity has been carried out. Activities may also be assigned a specific time frame.

A second manner to help learners in following a trail is to provide them with a navigational guide. This is described in Chapter 3. This type of help is relevant if learners can choose their own route. The navigational guide described in Chapter 3 is a visual map. The map shows the learner those LOs that the learner has passed and those LOs that the learner has not yet passed, but that may be of interest to the learner or that the learner needs to pass to attain a certain level of achievement. Within the map, the learner can click on a specific LO to start working on it. This map is created and updated from information stored in a personal profile of the learner.

From non-digital LOs a learner can create a digital trail by recording these objects and by taking notes. To this end learners need hardware devices that can record objects and record notes. Chapter 4 discusses requirements for such devices in the case of recording a museum visit. One relevant point is that the device should be multi-purpose. For example, a device should not only allow the learner to listen to an audio explanation on a particular

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object, but should also allow the learner to annotate the digitally available guide or else should allow the learner to combine working with the digital device and traditional guides and notebooks. In this chapter it was shown that this requirement is not easily met. This chapter also discusses hardware requirements for digital devices such as size, weight and battery life.

Learners may wish to reflect on their trails in order to improve their performance. This requires that any 'results' produced by the learner be presented to the learner in a format that provides useful information in an understandable way. Chapter 5 describes how trails within a discussion can be labelled and displayed to make them accessible to inspection by the learner. Each discussion contribution is analysed into several messages. Each message is provided with labels that indicate the contributor, the unique id number, a list of messages with which it expresses agreement and a list of messages with which it expresses disagreement. The messages and their relations are presented in a graphical form.

Several chapters touch upon the issue of personalisation of trails – adapting trails to the needs and interests of learner. To make personalisation of trails possible, it is necessary to collect data on the learners and from the learners' actions. Data collection is the topic of Chapter 7. This chapter begins with explaining the usefulness of data collection to working with trails. After that is discusses several technical details, namely the kind of data that can be collected, the tools that can be used for collection and the formats in which data can be collected. Finally, Chapter 7 shows how trails can be classified, retrieved and represented.

Supporting learners in working with trails is not restricted to individual learners. There are at least three ways in which collaborative learning with trails can be supported:

1. Within a learning design, trails can be set up that can or must be followed by a group or by individuals. By assigning specific roles to specific learning activities and by assigning specific persons and specific LOs to these roles and activities, different trails can be authored for different roles, and moments can be created in which these trails come together in one collaborative trail. The existing IMS Learning Design is one way in which this process is formalized.

2. Within a set of LOs, the aggregate statistics of their use by particular individuals or groups can be analysed to understand, predict and recommend the type of LOs learner are interested in. Based on these statistics, a visualization can be made of the LOs that have been visited by a group or by an individual, and of the LOs that have not yet been visited. This type of visualization can function as a guide to the group in choosing their route through the LOs.

3. Within a discussion, the trail of an individual can be analysed afterwards. This analysis can reveal all kinds of information related to the role of the individual within the group, for example the type of preferred reaction that the individual gives to messages of other group members and the extent to which the individual contributes to the discussion.

1.5 A taxonomy of trails

The different types of trail that have been discussed in the various chapters are brought together and classified in a taxonomy of trails, which is described in Chapter 8. A first distinction is made between trails proper and graphs, which may contain several trails. Trails are linear sequences of LOs. Graphs contain possible trails, and can be divided into learning environments and mind maps depending on the types of link between LOs.

It is not difficult to apply this distinction to the trails described in the various chapters. Designed trails containing sequences, described in Chapters 2 and 6, are graphs – the learning environments provided to the learner, in which they can create their trails. The visualization of Chapter 3 is a graph of the mind map type: it shows the learner the possible trails to follow based on the conceptual links between LOs. Trails in mobile learning and discussions, described in Chapters 4 and 5, are trails: they are routes that have been followed by the learners.

A further classification can be made according to the majority type of LO within the trail. Here a distinction is made between LO trails, discussion trails and result trails. Within this classification the trails of Chapter 3 are LO trails, those of Chapter 4 are result trails and those of Chapter 5 are discussion trails. Within this classification, many of the trail types described in Chapters 2 and 6 must be considered a combination of several smaller trails of the various types.

1.6 Conclusions

This deliverable achieves the several objectives laid out in the project proposal. First, it describes two methods by which digital and non-digital learning objects can be integrated. The first way is by means of digital placeholders. By a digital placeholder we mean a digital object that accompanies a visit to the non-digital LO, e.g. the audio tour accompanying a museum visit. The second way to integrate digital and non-digital LOs is by means of the digital results that learners create in reaction to non-digital objects. An example is the notes that a learner makes regarding a particular painting. These two means, digital placeholders

and digital result objects, can be combined within a trail, e.g. in the case of a learner who reads questions regarding a particular painting (= a digital placeholder) and answers these questions, thereby creating digital result objects.

The second objective of this deliverable is to describe the challenges which trails present to learners in terms of navigation, revisiting and refinement. Two types of navigation issues have been discussed. The first is the kind of learning environments that can be set up to make it possible for the learner to follow a trail. The other navigational issue is aid in the form of a navigational map. Revisiting trails is discussed first in relation to the navigational map, which is also an aid in revisiting trails. Revisiting is especially relevant in the case of result trails and discussion trails created by the learner. Chapter 5 has shown ways of labelling discussion trails in such a way that the learner benefits from revisiting the trail and reflecting on it. Refinement of trails is discussed in Chapter 3, where the results of learners in working with LOs leads to an updating of the personal profile and an updating of the navigational map.

The main objective of Kaleidoscope as a network of excellence, and thus of work in TRAILS, is the integration of research on technology enhanced learning that is carried out across Europe. As far as trails are concerned, the taxonomy presented in Chapter 8, makes a promising start in achieving this objective. The taxonomy is the condensation of a discussion in which the several types of trails were brought together, in which decisions were made on common labels and finally on a common classification.

These results together provide a solid basis to build upon in the second half of the TRAILS project.

1.7 Contributions

Although this document has been collaboratively written, and all sections benefit from the feedback and corrections of all authors, the bulk of the writing for each chapter comes from a single institution. Chapters 1 and 2 are from the University of Amsterdam, Chapter 3 is from Eotvos Lorand University, Chapters 4 and 5 from the UK's Open University, Chapter 6 from Institut d'Informatique et Mathématiques Appliquées de Grenoble, Chapter 7 from ATOS Origin and Chapter 8 from Birkbeck, University of London.

About Chapter 2

In this chapter several basic distinctions are introduced that will return in later chapters. The first distinction relates to stages. Different pedagogical approaches are characterized by different stages through which learners pass. We show that these stages are relevant in describing trails. Secondly, a first attempt is made to classify trails and their constituent learning objects. A distinction is made between trails that consist of visits to (i) pre-fabricated learning objects (ii) results created by the learner and (ii) discussion messages. Thirdly, a distinction is made between trails that have been laid out as a route for the learner to follow and trails that have been created by the learner, by following a route or in any other possible way.

2   Trails in various pedagogical approaches

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2.1   Trails in five pedagogical approaches

2.1.1 Introduction

This chapter describes trails in several pedagogical approaches. The approaches included are problem-based learning, progressive inquiry learning, discovery learning, cognitive apprenticeship and classroom learning. The ideas are based on work done by the University of Amsterdam in the EU-IST CELEBRATE project (see Schoonenboom and Roozen 2003, Sligte et al. 2003, Sligte, Roozen, Schoonenboom and Emans 2004).

In describing trails an important distinction is the one between planned and effected parts of trails. A trail consists of a planned part and an effected part. The planned part is the route that has been planned, either automatically or by hand, but that has not yet been followed by the learner. The effected part is the trail that has been followed by the learner. A trail that only has a planned part, we will call a planned trail. A trail that has been followed completely (contains only an effected part), we call an effected trail.

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There are differences between the possible constituents of planned parts and effected parts of a trail, e.g.:

- A planned part may include a decision to be made by the learner to choose between visiting several LOs.

- An effected part of a trail does not include decisions, but it may contain the results of decisions, namely that a visit is paid to some LOs and not to others.

- Another difference is that an effected part of a trail may contain results of visiting a LO. E.g. if a LO contains multiple-choice questions, the results of answering the questions can be stored and displayed in the effected part of the trail.

- A planned trail can only refer to LOs that are present at the moment of planning. An effected trail may contain LOs that are put there during the learning process. This applies especially to discussion trails.

In describing the trails in the various pedagogical approaches, for each step in each approach, the following characteristics are provided, if these are present:

Planned individual trail	Characteristics of planned individual trails for this step
Planned collaborative trail	Characteristics of planned collaborative trails for this step
Typical kind of LO	Kind of LOs that are typically planned or visited in this step
Relevant metadata of LO or of trail	Metadata that are relevant to describing either the trail or the LOs in this step
Effected individual trail	Characteristics of effected individual trails for this step
Effected collaborative trail	Characteristics of effected collaborative trails for this step

2.1.2 Trails in problem-based learning

In problem-based learning, students develop knowledge and expertise in a field by working on real life problems. In problem-based learning, the starting point is always the problem, in medical education often a patient with specific symptoms.

Problem-based learning involves the following steps:

Problem identification	A problem description is provided. This is an authentic problem, including all relevant aspects. In groups, students use the problem description in defining the problem.
Data collection	The students collect data needed to solve the problem.
Assessment	The relevance of the data to the problem is discussed.
Recommendation	A solution, and if necessary a treatment to the problem is given.
Evaluation of the solution	The students decide how appropriate their recommendation is.

The table below lists the occurrence of trails in problem-based learning. See the previous section for an explanation of the headings:

Steps in problem-based learning	Planned individual trail	Planned collaborative trail	Typical kind of LO within planned trail	Relevant metadata of LO or of planned trail	Effected individual trail	Effected collaborative trail
1. Problem identification	Non-existent	Non-existent	N/A	N/A	Reaction = own input	Collaborative trail of reactions to 1
2. Data collection	Decision between alternative LOs, either unlimited choice or limited choice	Different decisions for different roles or individuals	Rough data, pieces of information	Additional information, topic	Trail of visited and not-visited LOs	Several individual trails of visited and not-visited LOs
3. Assessment	Non-existent	Non-existent	N/A	N/A	Reaction to 2	Collaborative trail of reactions to 2
4. Recommendation	Non-existent	Non-existent	N/A	N/A	Reaction to 3	Collaborative trail of reactions to 3
5. Evaluation of the solution	Non-existent	Non-existent	N/A	N/A	Reaction to 4	Collaborative trail of reactions to 4

Conclusion on trails in problem-based learning

The use of trails in problem-based learning is mostly confined to the decisions that students make in searching for and the examining data. Recorded effected trails can be used to reflect on this process by reflecting on the decisions that have been made. In this collaborative

approach, personal profiles and roles can be useful in dividing the data to be examined among the students. Furthermore, the effected trails in discussions between students can be evaluated.

2.1.3 Trails in inquiry learning

In inquiry learning students set up and test hypotheses and theories by studying related phenomena. The goal of inquiry learning is that students acquire knowledge that may support, refute or refine their hypotheses. Inquiry learning differs from problem-based learning, in that the emphasis is more on generating theories rather than on solving a particular problem. Like problem-based learning, inquiry learning is a collaborative approach.

Inquiry learning involves the following steps:

Creating context	The students set up common goals.
Setting up research questions	Students generate their own research questions.
Constructing working theories	Students set up hypotheses that answer their research questions.
Evaluate working theories	Students evaluate the hypotheses.
Data collection and analysis	Data is collected that may refine the hypotheses.
Generate subordinate questions	Based on the data, more refined, subordinate research questions are set up.
Constructing new working theories	Based on analysis of the data, new working theories are set up.
Creating context etc	The cycle starts again…

The table below lists the occurrence of trails in inquiry learning:

Steps in inquiry learning	Planned individual trail	Planned col- labora- tive trail	Typical kind of LO within planned trail	Relevant metadata of LO or of planned trail	Effected individual trail	Effected col- laborative trail
1. Creating context	Non-exis- tent	Non-exis- tent	N/A	N/A	Trail of reactions to 1 and to others	Collaborative trail of reac- tions = own input
2. Setting up research questions	Non-exis- tent	Non-exis- tent	N/A	N/A	Trail of reactions to 2 and to others	Collaborative trail of reac- tions = own input
3. Constructing working theories	Non-exis- tent	Non-exis- tent	N/A	N/A	Trail of reactions to 3 and to others	Collaborative trail of reac- tions to 2
4. Evaluate these	Non-exis- tent	Non-exis- tent	N/A	N/A	Trail of reactions to 4 and to others	Collaborative trail of reac- tions to 2
5. Data collec- tion and analysis	Decision between alternative LOs, either unlimited choice or limited choice	Different decisions for different roles or in- dividuals	Rough data, pieces of information	Research topic	Trail of vis- ited and not-visited LOs	Collaborative trails of vis- ited and not- visited LOs
6. Generate subordinate questions	Non-exis- tent	Non-exis- tent	N/A	N/A	Trail of reactions to 6 and to others	Collaborative trail of reac- tions to 5
7. Constructing new working theories	Non-exis- tent	Non-exis- tent	N/A	N/A	Trail of reactions to 7 and to others	Collaborative trail of reac- tions to 6

Conclusion on trails in inquiry learning

The use of trails in inquiry learning is almost the same as in problem-based learning. Trail use is mostly confined to the decisions that students make in searching for and the examination of data. Effected trails can be used to reflect on this process by reflecting on the decisions that have been made. In this collaborative approach, personal profiles and roles can be useful in dividing the data to be examined among the students. Furthermore, the effected trails in discussions between students can be evaluated.

2.1.4 Trails in discovery learning

In discovery learning students themselves discover some 'scientific law'. Discovery learning is most often used in science education. The type of LO that fits in very well with discovery learning is the simulation.

Discovery learning involves the following steps:

Orientation	The students develop their first ideas about the domain, for example by reading background information.
Hypothesis generation	The students develop hypotheses, often about the relationship between two variables.
Hypothesis testing	The hypotheses are tested.
Conclusion	The hypotheses are accepted, rejected or refined.

The table below lists the occurrence of trails in discovery learning:

Steps in dis-covery	Planned individual trail	Planned col-laborative trail	Typical kind of LO within planned trail	Relevant metadata of LO or of planned trail	Effected individual trail	Effected col-laborative trail
1. Orientation	LO	LO	Simulation	Difficulty	Results of simulation	Discussion trail
2. Hypothesis generation	Non-exis-tent	Non-existent	N/A	N/A	Reaction to 1	Discussion trail to 1
3. Hypothesis testing	LO	LO	Simulation	N/A	Results of simulation	Results of simulation
4. Conclusion	Non-exis-tent	Non-existent	N/A	N/A	Reaction to 3	Discussion trail to 1

Conclusion on trails in discovery learning

The most relevant trail in discovery learning is the effected trail in the simulation. Note that the simulation in this sense is a special LO, in that an effected trail within the object is created. Planned trails are not so relevant in inquiry learning. Recorded effected trails can be used to reflect on the process of testing the hypothesis. The personal profile may be used to determine the right difficulty of the simulation. Furthermore, the effected trails in discussions between students can be evaluated.

2.1.5 Trails in cognitive apprenticeship

In cognitive apprenticeship, the students learn by interacting with experts. Students learn by first watching the experts, and then gradually increase their own rate of participation.

Cognitive apprenticeship involves the following steps:

Observe examples	The learner watches how experts do their job.
Ask questions	The learner asks questions to the experts.
Do simple exercises	The learner starts with very simple exercises, which gradually get more difficult.
Role-playing	The learner practices different roles of the expert.
Expose own work	The assessment consists of producing and exposing a piece of work.

The table below lists the occurrence of trails in cognitive apprenticeship:

Steps in cognitive apprentice-ship	Planned individual trail	Planned collabora-tive trail	Typical kind of LO within planned trail	Relevant metadata of LO or of planned trail	Effected individual trail	Effected collabo-rative trail
1. Observe examples	Trail of ex-amples; may include some choices	Different examples for different roles or in-dividuals	Example	Difficulty of LO plus difficulty of trail	Trail of LOs visited and LOs not-visited	Collabo-rative trails of visited and not-visited LOs
2. Ask ques-tions	Non-existent	Non-exis-tent	N/A	N/A	Trail of questions and reactions to answers	Collabo-rative trail of questions and reactions to answers
3. Do simple exercises	Trail of ex-ercises; may include some choices	Different exercises for different roles or in-dividuals	Exercise	Difficulty, topic	Trails of LOs visited and LOs not-visited; results of exercises	Collabo-rative trails of visited and not-visited LOs
4. Role-playing	Non-existent	Non-exis-tent	N/A	Role	Trail of re-actions	Collabo-rative trail of reactions
5. Expose own work	Non-existent	Non-exis-tent	N/A	N/A	Summary = reaction to whole trail	N/A

Conclusion on trails in cognitive apprenticeship

In cognitive apprenticeship, planned and effected trails of examples and trails of exercises are important. With trails of both exercises and examples, an increasing level of difficulty should be implemented. With the planned trails, the results of the exercises can be used in reflection and in discussion with the students. Sometimes it will be possible to adapt the

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planned trail of the exercises based on the results up till then. The personal profile may be used to determine the right difficulty of the examples or of the exercises. In role-playing and asking questions to experts, discussion trails become important. Here the role of each participant should be indicated (learner versus expert).

2.1.6 Trails in classroom learning

Unlike the foregoing approaches, classroom teaching is not a specific method. However, in general, most classroom teaching occurs in a typical order. That is why trails are important here as well. The typical classroom order is:

Introduction	The subject matter is introduced to the students
Exercise	The students do some exercises on the topic
Assessment	An assessment is performed, to check whether the students master the subject matter.

The table below lists the occurrence of trails in classroom learning:

Steps in classroom learning	Planned individual trail	Planned collaborative trail	Typical kind of LO within planned trail	Relevant metadata of LO or of planned trail	Effected individual trail	Effected collaborative trail
1. Study introduction	Introductory LO	Different LOs for different roles or individuals	Introduction	Topic	Introductory LO visited	Collaborative trails of visited and not-visited LOs
2. Do some exercises	Trail of exercises	Different exercises for different roles or individuals	Exercise	Difficulty, measuring results, adaptation	Results of exercises	Collaborative trails of visited and not-visited LOs
3. Do an assessment	Assessment LO	Different assessment LOs for different roles or individuals	Assessment	Difficulty, measuring results, adaptation	Results of assessment	Collaborative trails of visited and not-visited LOs
Whole design	N/A	N/A	N/A	Learning objectives, learning style	N/A	N/A

Conclusion on trails in classroom learning

In classroom learning, planned and effected trails of exercises are important. An increasing level of difficulty should be implemented. To best fit the learning style of the student, the

order between introduction and exercise may sometimes be reversed, the trail may be fixed or give the student some choice. With the planned trails, the results of the exercises can be used in reflection and in discussion with the students. Sometimes it will be possible to adapt the planned trail of the exercises based on the results up till then. The personal profile may be used to determine the right difficulty and learning style of the introduction or of the exercises.

2.2 Types of trail

From the pedagogical approaches some typical trails emerge. These will be discussed in this section. We can identify two main types of trail and also some other elements necessary for creating trails but that are not themselves trails. The first category is planned trails. The second category is effected trails. There is also the third category containing elements that are not trails themselves, but that are necessary elements for creating trails. Although some types of effected trails do not originate in planned trails (e.g. a discussion), there are other kinds of elements that are a prerequisite to creating the effected trails. These are listed in this third category.

The planned trails include:

Fixed introduction and exercise trail	These trails are built of exercises and/or introductory LOs. The exercises may have containers for storing the results. There is one route, hence the prefix 'fixed'. This fixed route may be based on the personal profile of the learner. This trail type is associated with cognitive apprenticeship and classroom learning.
Adaptive introduction and exercise trail	These trails are built of exercises and/or introductory LOs. The exercises have containers for storing the results. The corresponding effected trail is partly dependent on the results to exercises. Based on the results in the effected part of the trail, the system adapts its planned trail. This trail type is associated with cognitive apprenticeship and classroom learning.

The effected trails include:

Discussion trail	A discussion trail is created by the interaction of learners with one another. It typically consists of elements, 'LOs', that emerge during the learning process and that were not present at the beginning. This trail

	can be used to set up a personal 'discussion profile'. It can also be used in characterizing the discussion. This trail type is associated with all pedagogical approaches.
Visit & result trail	A visit & result trail lists the LOs that the learner has visited and the results, as well as the LOs that have not yet been visited. This trail type may be used in adapting the planned trail. The results may be added to the personal profile. The trail may be used to determine how far individual students have advanced in 'doing' the LOs. This trail type is associated with cognitive apprenticeship (both example and exercise trails) and classroom learning (both introductory and exercise trails).
Data selection trail	A data selection trail lists the data that the student has selected and visited, and may also list relevant data that has not been selected. The trail can be used when discussing the decisions that the student has made. This trail type is associated with problem-based learning and inquiry learning.
Simulation trail	A trail through a simulation shows the subsequent parameters that the student has manipulated to test the hypotheses. It can be used in discussing the learner's method of hypothesis testing. This trail type is associated with discovery learning.

The third category is the elements necessary to create effected trails, which are not trails themselves. These include:

Data to be searched	The LOs that belong to this category include mostly 'rough data', information objects. Since no route is planned through the data, there is no planned trail. This element is associated with problem-based learning and inquiry learning.
Discussion platform	A discussion platform is a necessary element for creating discussion trails. This element is associated with all pedagogical approaches.
Simulation	A simulation is one LO, and hence not a planned trail. Within a simulation the learner can create an effected trail. This element is associated with discovery learning.

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The table below gives an overview of these classifications, and lists:

Metadata of LOs within trail	The relevant metadata that should be added to the LOs that are part of the trail.
Metadata of trail itself	The relevant metadata that should be added to the trail as a whole.
Characteristics of personal profile	Characteristics of the personal profile that may be used in creating a planned trail of this type or that may be added to the personal profile, based on an effected trail.

Again, some metadata can be added beforehand, while the learner provides the values of some other metadata fields. The first type of metadata can be used in plotting trails, the other type in evaluating trails:

- Pre-authored metadata of LOs and trails useable in planned trails include: topic, difficulty, learning objective, learning style, collaborative/individual, role;

- Metadata of LOs and trails for which the values are created by the learner, and which are thus part of the effected trail include: visited/not-visited, popularity, results, reaction type (in a discussion), selected/not-selected, discussion thread to which the LO or trail belongs, role.

	Metadata of LOs within trail	**Metadata of trail itself**	**Characteristics of personal profile**
Planned trails:			
Fixed introduction and exercise trail	Topic, difficulty, intro/exercise, collaborative or not, some learning style elements, role	Learning objective, learning style, role	Learning style, visited or not-visited LOs
Adaptive introduction and exercise trail	Topic, difficulty, intro/exercise, collaborative or not, some learning style elements, choice for next LO, role	Learning objective, learning style, role	Learning style, visited or not-visited LOs, level of achievement
Elements necessary to create effected trails that are not trails themselves:			
Data to be searched	Topic, some learning style elements	N/A	Learning style
Discussion platform	N/A	N/A	N/A
Simulation	Topic	N/A	Learning style
Effected trails:			
Discussion trail	Type of reaction	Metadata of individual trails: type and number of reactions, discussion threads, role Metadata of collaborative trail: number of reactions, discussion threads	Reaction patterns
Visit & result trail	Topic, difficulty, intro/exercise, collaborative or not, some learning style elements, choice for next LO, results	LOs that have been visited versus those that have not, score	Level of achievement, topics of interest, LOs that have been visited versus those that have not, score
Data selection trail	Topic	LOs that have been selected versus those that have not	LOs that have been selected versus those that have not
Simulation trail	N/A (the trail is created within the simulation LO)	N/A (the trail is created within the simulation LO)	Level of achievement

About Chapter 3

One basic distinction introduced in Chapter 2 was the distinction between trails that have been laid out as a route for the learner to follow and trails that have been created by the learner, by following a route or in any other possible way. Chapter 3 elaborates on this distinction. A trail that has to be followed consists of learning objects that have not yet been visited by the learner. As the learner proceeds, more and more learning objects are being visited and receive the status of a visited learning object. Chapter 3 shows how it is possible to visualize visited and non-visited learning objects in a map, which can then be used by the learner as a navigational map.

3   Adaptive navigation support

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3.1   Adaptive navigation support in an English grammar course

3.1.1 Rationale

Existing educational web-portals struggle with many of the same problems as web-portals in general, as well as some problems specific to the educational domain:

- it is difficult to navigate within the structure of the topics
- there is a lack of personalized methodological guidance
- there is no appropriate information on the usability, the effectiveness and the success rate of the learning material
- special needs are rarely satisfied

3.1.2 Theoretical background

Adaptive hypermedia systems are capable of altering the content or appearance of a hypertext on the basis of a dynamic understanding of the individual user. Information about a particular user can be represented in a user model and used to alter the information presented. We define these systems as "...all hypertext and hypermedia systems which

reflect some features of the user in the user model and apply this model to adapt various visible and functional aspects of the system to the user".

More specifically, Adaptive Navigation Support (ANS) is a generic name for a group of techniques used in adaptive hypermedia systems that use this model to provide directional assistance to the user (Brusilovsky et al., 1996). For example, suggesting where the user should proceed, or annotating what is learned and what is ready to be learned.

Adaptive navigation support techniques can be classified into several groups according to the way they adapt the presentation of links – direct guidance, sorting, hiding, and annotation (Brusilovsky, et al. 1996).

Adaptive annotation technology augments the links with a comment that informs the user about the current state of the nodes behind the annotated links (Schwarz et al., 1996). Link annotations can be provided in textual form or in the form of visual cues, for example, using different icons, colours, font sizes, or font types. Typically the annotation in traditional hypermedia is static and independent of the individual user. Adaptive navigation support can be provided by dynamic user model-driven annotation. Adaptive annotation in its simplest history-based form (outlining the links to previously visited nodes) has been applied in some hypermedia systems, including several World-Wide Web browsers. Even a form of adaptive annotation that simply distinguishes two states of links is quite useful (Eklund et al., 1997).

3.1.3 Hypothesis

We expected that students using non-linear computer-based learning material would need some support for their navigation. They need to know what kind of items within the material suits them personally the best in their individual learning process. We expected that the provision of a *personalised criteria based adaptive colour guidance map navigation support* for each student would make their progress in the material more effective.

3.1.4 Aims of research

Our aim was to investigate whether *personalised criteria based adaptive colour guidance map navigation support* helps students to master the material in a more effective way.

Beside this the experiment provides us the opportunity to investigate the usability of the material itself and the criteria-oriented test questions.

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3.1.5 Frame of research
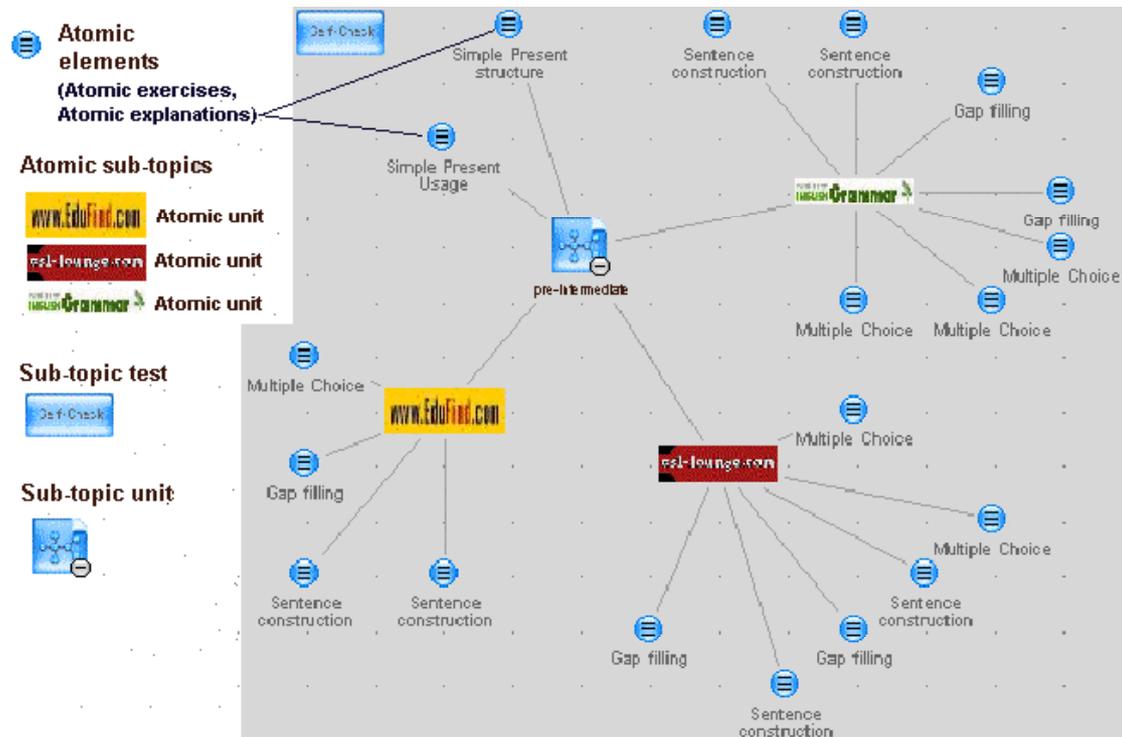
ELEMENTS OF THE SYSTEM

Figure 1. Illustration of the structure of elements in system

Atomic elements

We have dissected five free, good quality intermediate English language grammar teaching portals into *atomic elements* (grammar explanations and their exercises as *atomic elements* on specific topics), as links.

When selecting exercises as atomic elements, it is essential that each of them have a self-assessment opportunity, which is indispensable in case of autonomous distance learning systems. It is however the responsibility of the user to decide whether or not to take the self-assessment, thus we have no feedback on that.

Atomic units

An *LO* in this system is thus a LO in the form of an *atomic unit* related to a specific level within a specific sub-topic of English grammar, which consists of grammatical exercises as atomic elements belonging to the same site.

We have no feedback on what the student does while assessing atomic units. We came up with more than 500 atomic units from different portals that could be linked to our system.

Atomic sub-topics

All atomic units are categorised according to the sites they exist in and are collected into groups corresponding to the sub-topics involved. Thus, they provide the *atomic sub-topics* of the system.

Atomic sub-topic explanations

Some of the sites contained atomic explanations of which the best was selected as the *atomic sub-topic explanation* for each specific sub-topic.

Sub-topic tests

We have developed *tests* for each atomic sub-topic separately, which provide feedback to our system about results of student access. A *sub-topic test* consists of 3 examining questions in the same manner as in the general test, but concentrating on that single sub-topic. The test questions provide an objective evaluation because each question has only one correct answer.

Sub-topic units

A *sub-topic unit* consists of atomic subtopics and atomic subtopic explanations, belonging to the same sub-topic and a corresponding sub-topic test.

Classification of sub-topic units according to criteria

Sub-topic units are clearly classified into three difficulty levels (beginner/re-starter, pre-intermediate, intermediate) within the sub-topics of general intermediate English language grammar found in most language books (beginners to intermediate), referred to here as *criteria*. Thus students can easily recognise the topics and sub-topics due to evident similarities and identify levels the same way.

Diagnosing knowledge criteria

The categorising general grammar test is implemented with over 50 questions which is very similar to a usual intermediate English language grammar test that is able to filter and categorise the different deficiencies of learners within the existing levels (beginner/re-starter, pre-intermediate, intermediate) of grammatical topics and sub-topics. The system provides the learner with a chart containing his/her answers given during the test, the correct answers

and an indication of correctness or mistake (highlighting deficiencies). The test questions provide an objective evaluation because each question has only one correct answer.

Mapping deficiencies diagnosed with sub-topic units

The output from the diagnosis of knowledge criteria (highlighting deficiencies) is mapped to the exact set of cure sub-topic units (required topics within identified level as objectives to be practiced) in order to make improvements in mastering the English language grammar at intermediate level.

Data collection

An SQL database records student's profiles: the detailed results students attained in the tests (by topic and level) with specific knowledge and weakness points, as well as effected trails of students during online activities (log files).

General navigational map

The general navigational map is constructed from trails defined by a levelled grammatical structure, based on the natural topics of English language grammar. It consists of:

- *topic nodes* dressed up on a grammatical tree structure, corresponding to the different topics and sub-topics of English language grammar;
- within each topic node there are three *knowledge level nodes* (beginner/re-starter, pre-intermediate, intermediate);
- reaching to the leaves of the tree as *sub-topics units*.

Sub-topic units contain a group of options for *atomic sub-topics* found on different sites, with each trajectory enabling access to groups, atomic explanations and a *sub-topic test*.

Types of nodes

Node types are distinguished in the course of progress as *mastered nodes, unmastered nodes*, and *semi-mastered nodes* depending on the personalisation process, where students are tested for their knowledge levels within topics:

- *Mastered nodes* are nodes leading to trails containing materials that are already known by the learner, and are thus not necessarily recommended to be accessed. Nodes can be assigned this characteristic after the student takes the general grammar test, depending on the results. Mastered nodes are coloured blue.
- *Unmastered nodes* are nodes leading to trails containing some materials diagnosed as not known, and are thus indicated as recommended paths of which some should

be accessed in order to master the knowledge within. Nodes can be assigned this characteristic after the student takes the general grammar test, depending on the results. Unmastered nodes are coloured red.

- Nodes attain *semi-mastered* characteristics after the student accesses trails within unmastered nodes and successfully completes a self-test. After completing any sub-topic test successfully, the colouring of that particular sub-topic unit node of the map turns to yellow indicating it is *semi-mastered*. The yellow node represents a sub-topic unit that was previously diagnosed as *unmastered*, but at this instance the sub-topic test was successfully fulfilled, which means that it has a better chance of being diagnosed as *mastered node* the next time the student takes a general criteria test. If all nodes within a parent node have turned semi-mastered, then the parent node is also recoded as semi-mastered. That is, *Semi-mastered nodes* are nodes leading to trails that contain semi-mastered nodes only.

Node types leading to trails are independent of whether the student has previously accessed the node or not. Thus, there is no distinction in the system between *planned trails* (routes planned by a teacher to be taken by a student) and *effected trails* (routes that have actually been accessed by student). The fact of a trail or node being accessed is, however, recorded in the student's profile (log file).

In other words, *planned* nodes can be *untouched*, *touched* and *activated*, meaning: *untouched nodes* remain as *planned* trails, *touched nodes* are recorded as such, while *activated nodes* influence the state of student profile in terms of colouring as node type.

Presentation
To present the material we used the Coraler mapping tool. Coraler's curriculum map shows the students the material in the form of a mind map that is a multilevel graph, visualizing clearly the logical and content links.
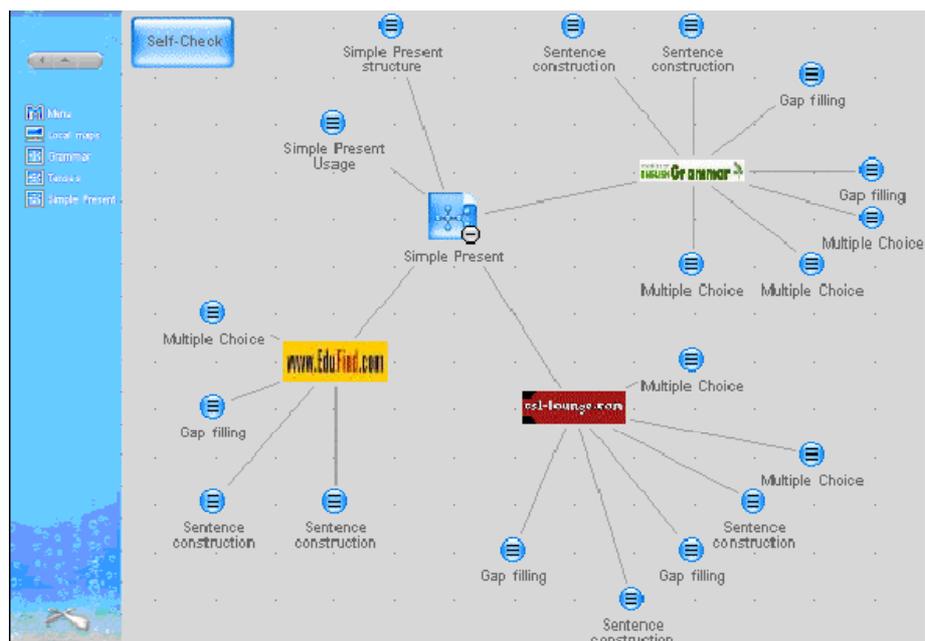
Figure 2. Illustration of a single sub-topic unit (this sub-topic unit does not have divisions of levels)

3.1.6 Process

When entering the course the student is presented with the general navigational map, which gives clues to all topics to be mastered within the English language grammar course.
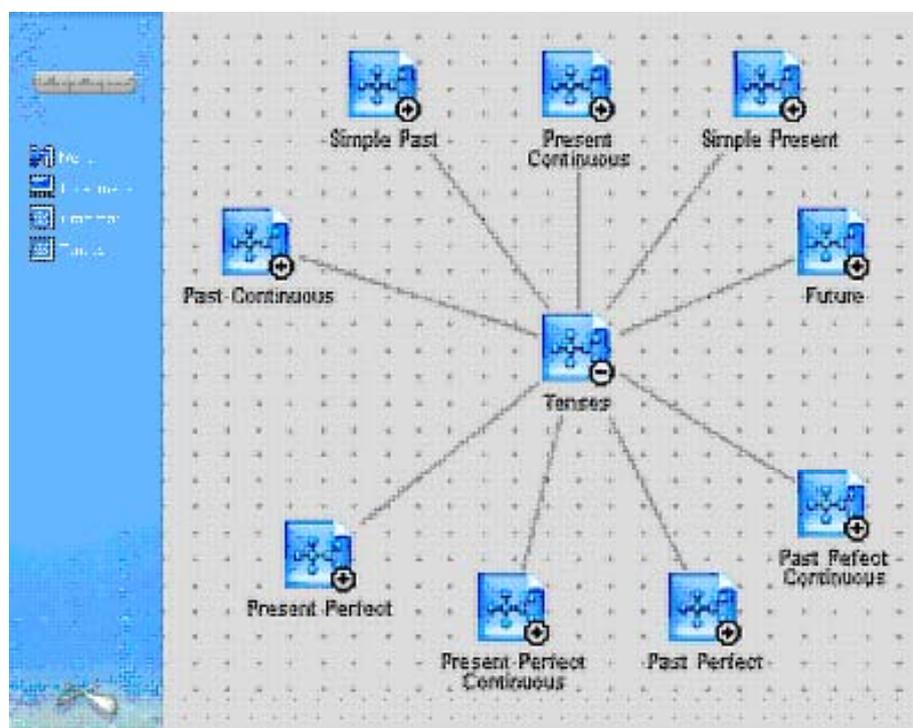

Figure 3. Illustration of a single topic node

The student first has to go through the general intermediate grammar test, which diagnoses his/her knowledge according to pre-defined criteria by examining his/her knowledge level in each English language grammar topic, specifying the exact sub-topic units of knowledge that have deficiencies and still need to be mastered. The student could see a chart with the answers given during the test as well as the correct answers.

After this general grammar test the student is presented with a *knowledge map* (a modification of the original general navigational map) in which the topics/sub-topics, where his/her knowledge is not satisfactory enough are distinguished using a different colour (red – indicating an unmastered node). This kind of colouring pinpoints to the student those sub-topics in the map where deficiencies were recorded (as well as providing the outline of an advised route for visiting the items of the material).
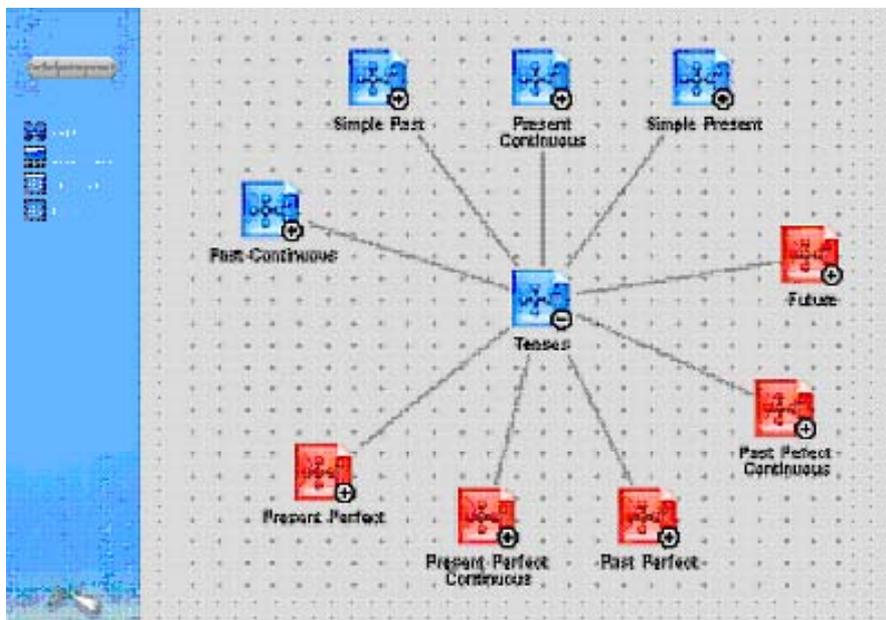
Figure 4. Illustration of a knowledge map

Thus the *knowledge map* is a modification of the original navigational map, personalised to each student at a specific time of assessment by dividing the types of trails into two distinguished sets:

- A set of trails containing those topics that are already mastered (i.e., mastered nodes, where the tests corresponding to these sub-topics have all been passed) and do not need to be revisited. They are coloured in normal colour (blue), indicating that it is not a recommended route to be taken; yet it is an existing route. Such trails are thus called *mastered trails*. Routes of mastered trails contain only mastered nodes, thus

the student can be confident in avoiding these trails, since they will not affect their learning progress.

- A set of trails containing those topics that are not all mastered yet (i.e., unmastered nodes, where some tests corresponding to these topics have not been passed). They are coloured to call for attention (red) indicating they are a set of recommended nodes to be taken. These trails are thus called *unmastered trails*. Routes of unmastered trails might contain some mastered nodes, but definitely do contain unmastered nodes. These nodes indicate advisory routes for students, which should be followed down their sub-structures of unmastered trails, until the *nodes of unmastered sub-topic units* are reached.

As self-assessment, students have the opportunity to fill in a self-test at atomic elements (but the system gets no feedback from these) and/or sub-topic tests at every particular sub-topic unit, from which system does receive feedback. After completing any sub-topic test successfully, the colouring of that particular sub-topic unit node of the map turns yellow (indicating that it is now semi-mastered).
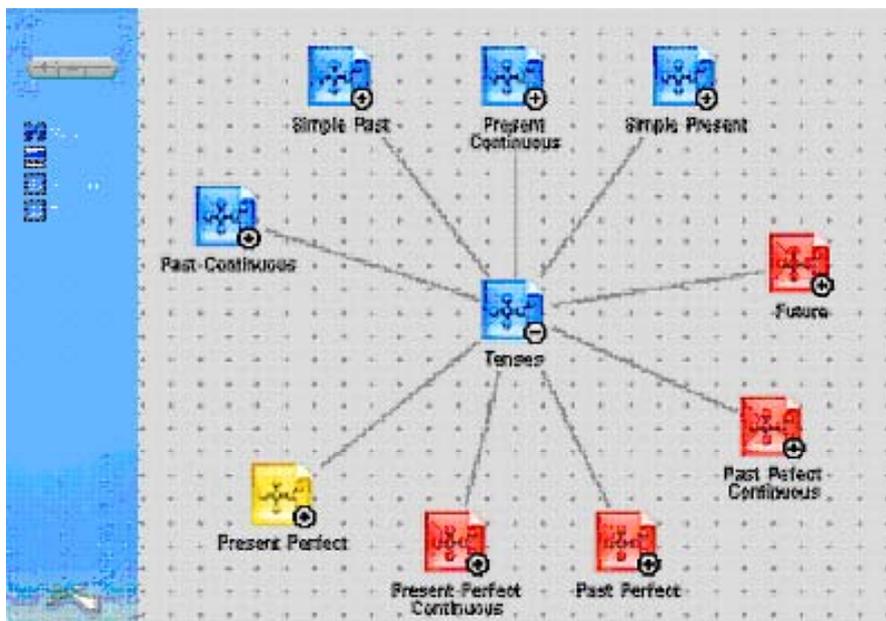
Figure 5. Illustrates a semi-mastered node

The yellow node represents a sub-topic unit that was previously diagnosed as *unmastered*, but now the sub-topic test has been successfully completed, which means that it has a better chance of being diagnosed as a *mastered node* the next time the student takes a general criteria test. However, the student should not be too self-confident, since this is only one instance when he/she was able to fulfil a test, which is not yet a proof. Some further

exercises are needed at other atomic units of the same sub-topic unit, and if a sub-topic test is fulfilled again, then there is an even better chance that the next time the student takes the general criteria test then this sub-topic unit node shall be diagnosed as *mastered*.

It should be noted that the change of node type and corresponding colouring (turning yellow) has a progressive characteristic towards parent nodes only if all nodes within the parent node have turned yellow. This means that the sub-topic has previously been diagnosed as *unmastered*, but now all sub-topic unit tests have been successfully passed at some point, meaning that there is a very good chance of it being diagnosed as a *mastered node* the next time the student takes a general criteria test.

If the sub-topic test wasn't successful the colour of the node of the particular sub-topic remains red, showing that it definitely needs more learning and practice. Thus the student receives negative feedback and is further advised to nodes that are coloured in red (as *unmastered* nodes).

The situation can also arise where students access nodes/trails that have not been advised (blue), yet they have for some reason been tempted to access nodes in that area. If they take a sub-topic test at any point and do not succeed, then the sub-topic unit node turns red together with all its parent nodes, indicating that even though the general criteria test diagnosed the student as being successful in this specific topic, there seems to be some deficiency, which might need some more investigation. That is, further exercises and tests are needed in that sub-topic area.
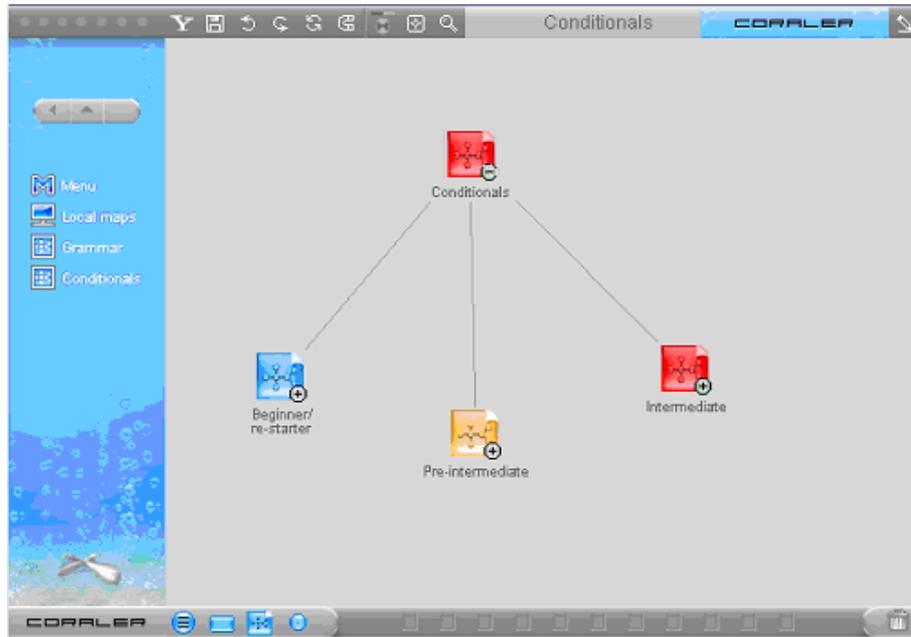
Passing Intermediate level

Figure 6. Illustration of the states at a particular instance (beginners/re-starter as blue, pre-intermediate as yellow, intermediate and parent as red)

Figure 6 illustrates an instance where the student has taken the general criteria test, which has indicated that he/she does not know the sub-topic of "conditionals" at level of "pre-intermediate" and "intermediate". The student followed the trail to this topic node and accessed the sub-topic unit's "pre-intermediate" level node, where he/she (probably performed some learning with exercises and then) took the sub-topic test of that level and passed it successfully. Thus this node became a semi-mastered node and coloured yellow. However, the knowledge map indicates that student should not be completely satisfied with the results, since this system intends to give her/him progress towards intermediate level of knowledge, thus the parent node is coloured red (an unmastered node) indicating that further learning on this topic is necessary.

Characteristics of the system

- The system is personalised in nature, since the general criteria test provides tailored advisory routes for each specific student as well as the sub-topic tests, re-colouring specific achievements;
- The system is adaptive in nature, since every active step of the student (processing an activated node) causes a change in the profile;

- The system is advisory in nature, since nodes of trails indicate only recommended routes that are not compulsory and leaves all other routes accessible as well;
- The system is self-diagnostic, since students are able to take the general criteria test at any point they wish, which would re-colour their knowledge map as a whole and produce a new additional profile for the student. (All previous profiles are stored in the log file.)

Pedagogically, this evaluation is a kind of "*criteria-based*" evaluation. Students progress according to their own abilities and the feedback about their improvement is not related to the achievement of other students taking part in the course. The aims of the examination after the end of the course is to map the knowledge acquired by the student during the learning process and to identify further areas where improvements are needed, with a personalised knowledge map as output.
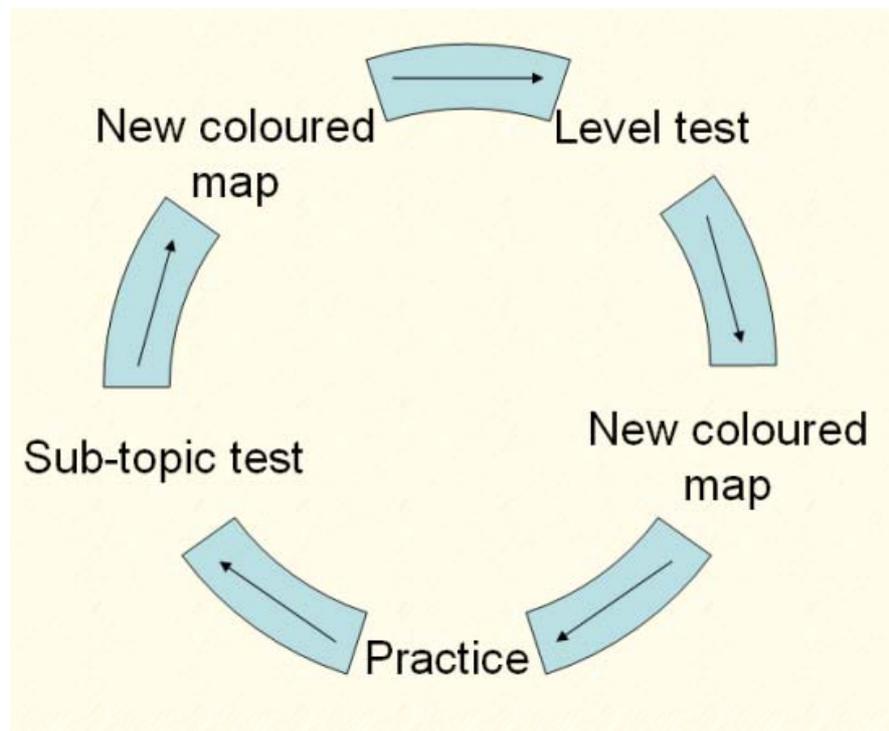

Figure 7. Illustrates the cycle of criteria-based learning

3.1.7 Setup of experiment

The method of 'action-research' was applied in this experiment. The first version of the pilot system was set up and the students could use it during February – April 2003. Data was collected on students' activities, feedback and e-mails. Another session is forthcoming.

The experiment involved more than 50 university students involved in informatics studies. In order to investigate the efficiency of this method, some of the students were not given the *personalised criteria based adaptive colour guidance map navigation support*, but instead had just the normal table of contents accessible by any user of the system.

3.1.8 Motivation

Students' motivation for using this course was to prepare for their language exam or just to have some practice for their own benefit, without any credits involved. After launching the course web site a lot of students wished to use the site, however our technical facilities were limited to 10 students in parallel. We had to put the rest in a queue and allow further registration if someone dropped out. In order to keep up the motivation of registered students we implemented a monitoring system that disabled accounts of users who had not been online for more than two weeks. This motivated students to work more or less in a continuous manner.

3.1.9 Evaluation, Results

After the experiment, we analyzed the data stored within the students' profiles. Our analysis consisted of three main parts:

- learning outcome
- learning material
- criteria diagnosis

Learning outcome

In the case of analysis of students' improvement we compared the students' progress who could see the colour-based adaptive navigation support to ones who could only use normal table of contents. According to the analysis we can say that students who used the *personalised criteria based adaptive colour guidance map navigation support* improved more than those who didn't. During the learning session the knowledge of the experimental group improved by an average 11.9%, while that of the control group using no support (just the table of contents) improved their score by an average 6.9%.

Learning material and criteria diagnosis

In the case of learning material and criteria diagnosis we were searching for their weak points. LOs not found to be effective enough were to be replaced with new ones, and diagnostic test questions that did not provide correct solution rates were also to be replaced.

Atomic sub-topics contain LOs from the same site, on the same topic, at the same level. They are thus grouped only to show the user that they belong to the same site. It will be interesting to measure what preferences users might have in accessing groups from the same source. Analysing information in log files could lead us to identify clusters, showing the preferences of students for different educational sites.

3.1.10 Conclusion

On the basis of the results of the experiment, our feedback and experiences we are perfecting the learning material, the evaluation test questions and the representation of the course. We shall be starting a new upgraded experiment with a higher number of students in order to be able to determine student clusters for achievements.

Learning objectives

The initial general guide is too broad and contains all objectives to be fulfilled. Some kind of personalisation is required in order to produce a set of clear objectives that are rational, understandable, and that gives a global picture of the objectives that really need to be fulfilled to the learner. Personalised practice, as such, proves useful for individual learning. Students can complement their language learning by going through necessary exercises in this course. They use the multilevel mind map as their guide in searching for objectives to fulfil. Their advisory guide just gives suggestions from which students have the freedom to choose or even access trajectories that were not advised if they wish.

Learning process

As a kind of distance leaning material, we didn't control the exact route or time to be spent doing these exercises in the course. Students can freely browse along all trajectories as they wish, since the adaptive navigation support is just a feature that it is not compulsory to use. However, when used it provides a criteria-based navigational support personalised for each student automatically during the process of learning.

We were interested to see if any kind of clusters would appear, that might show preferred learning processes, and later we might investigate the differences in learning styles (this possibility has not yet been investigated fully).

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3.2 Using mind maps to record personal trajectories of digital and non-digital LO trails

3.2.1 Rationale

It is difficult to record trajectories containing knowledge that is gained through non-digital LOs. One approach could be to find a way a way for students to record their own trajectories during the learning process, for example using the utility of mind maps.

Though there are several types of computer-based concept mapping tools, observations reveal that pupils rarely use concept mapping spontaneously because it is difficult and the process of map modification is messy and cumbersome. A suitable mind-mapping tool is needed, one that could be part of the learning system, that students get used to while accessing digital materials. This would make it easier for them to author their own trajectories.

3.2.2 Theoretical background

Jonassen et al. (Jonassen, et al, 1993) defined concept maps as "*representations of concepts and their interrelationship that are intended to represent the knowledge structures that humans stored in their minds*". While concept maps are formed by nodes (represented as lexical labels) and links (represented as lines) having individual labels between nodes, mind maps can be more freestyle, visual and do not necessarily have particular meanings imposed on relationships (Buzan, 1995). Bruillard et al. summarises the main characteristics based on a review of the scientific literature devoted to issues related to computer based concept mapping as a learning tool, taking into consideration that knowledge is constructed through observation of events or objects in relation to the concepts already known (Bruillard, et al, 2000):

- Concept maps help to access representation as a given state in learning, which can be more easily produced by children since it involves more of drawing than of writing processes.
- Concept maps are communicational tools to share content and ideas in their complexity.
- Concept maps are useful for collaborative activities, where existing representations can be easily modified if created using computer tools.

- Concept maps have proven to be useful teaching tools in lesson design for identifying key concepts and their relationship, and for building the whole structure of the curriculum as a content analysis tool in itself. During the progress of the learning phase it represents a change in the learner's mind compared to previous states of knowledge, thus it represents the knowledge map of the learner (Kaszas, et al, 2003).

- Creating concept maps is an effective constructive learning process since it requires explication, reflection and enhances critical thinking.

- Using concept maps in the context of hypertext, they are suitable as a navigation tool within educational materials and in assisting reading comprehension within complex text.

Concept maps can be good instruments of empirical evaluation. During the evaluation of the image-based, brainstorming-style, concept mapping task used at ImpacT2 on the theme "*Computers in my world*", done by children aged between 10-16, five quantitative measures emerged from heuristic analysis of the maps: counting the number of nodes, counting the number of links, calculating the ratio between them to give a "connectivity score", categorising of maps through phenomenographic analysis into "*Spheres of Thinking*" and also into "*Zones of Use*". The correlations between the data obtained and other data gathered from students suggest that the concept mapping scores provide valid significant indicators of the pupil's experiences of ICT and the breadth and complexity of their "secondary artefacts" of networked technologies (Mavers, et al 2002). The evaluation further suggests inclusion of colour within these maps to allow a very sensitive representation of concepts that mirrors the mood and preference of the presenter as well; however, it was not included within this research.

Though scientific literature cannot as yet prove any significant improvement in the effectiveness of educational materials visualised as links between concepts, the construction process of concept maps does prove to lead to effective learning within constructivist approach (Bruillard, et al, 2000).

It is very important to enhance the abilities of computer based concept mapping tools, but at the same time allow ease of use and flexibility of expression in order to reduce the cognitive load for users presented by the tool itself and to promote self expression. Any concept mapping tool should allow the freedom of expressing concepts and mirroring knowledge and mood in a fluent way, as with pencil and paper or the easiest of computer based painting

tools. They can be used as valuable tools in monitoring the cognitive states of knowledge acquired by learners.

The Coraler (www.coraler.com) mapping tool simplifies the process of finding, retrieving, organizing and understanding information and sharing knowledge online. Coraler has two main parts: mapEditor and mapViewer. Coraler mapEditor allows users to create and publish information maps with simple drag & drop operations. MapViewer displays information maps with any Java (or Flash) enabled browser and eliminates the need to install and additional software. Coraler mapEditor allows the organisation of thoughts as links between nodes within a concept map. Clicking on the group nodes we can travel one layer underneath till we reach the concrete nodes of web links or files. Thus the Coraler mapping tool can be thought of as a tool that is more informative than a general browser, allowing visual organisation of web links.

3.2.3 Hypothesis

The Coraler mapping tool is a suitable tool for children to construct highly structured maps with flexible content and interpretation for recording digital and non-digital LOs.

Concept maps or mind maps, as learning tools, mirror the knowledge constructed through observation of events or objects in relation to the concepts already known, thus they are suitable for recording the changes in learners' knowledge spaces.

3.2.4 Aims of research

Our aim in this research is to investigate different scenarios where learners navigate through digital and non-digital LOs and attempt to record the knowledge they gathered as well as feelings towards it by using multimedia in their expressions.

3.2.5 Frame of research

TeaM Challenge games set up an environment for 10-14 year old students, to raise their interest in relevant topics towards the process of complex problem solving in team collaboration while being able to trace the sources of the elements for their solutions.

TeaM Challenge 2002: "Get to know your country Hungary through the Internet"
(http://kihivas.ini.hu).
The game has been carried out as a course deliverable at TeaM lab
(http://www.team-lab.ini.hu).

TeaM Challenge 2003: "Get to know the European Union through the Internet"
(http://kihivas2003.neumann-centenarium.hu/)

The game has been carried out with the support of John von Neumann Computer Society (http://www.njszt.hu).

TeaM Challenge 2004 "Get to know the world through the Internet"
(http://kihivas.inf.elte.hu/kihivas2004/).

The game has been carried out with the support of KOMA (Hungarian Fund for the Modernisation of Public Education).

LOs

TeaM Challenge is an Internet problem solving game containing three types of LO:

- Those concentrating on complex riddles to be solved.
- Those requiring thorough analysis of specific data or topics.
- Those invoking synthesis of collected and analysed information in the form of a mind map hyperlinking further information into web pages.

We did not provide digital resources, instead we have gave the players more complex, natural and contextualised problems and urged them to search the entire Internet and to use other printed or electronic resources found at home, in the library or gathered through e-mail requests. As a result of this the task required creative solutions from the participants, and it also became more natural and life-like problem solving.

Learning objectives

To provide a task that requires (i) pre-planned searching and selecting amongst information the Internet provides, and (ii) filtering information that feels relevant to the required solution. The task of students was not only to provide the solutions to problems given, but also to specify the exact sources where they found their information, in the form of internet links, descriptions of books or CDs, e-mails in which they have inquired for information, or oral forms of inquiry they made. Also they had to describe the logics and tools used in producing a solution. We accepted all solutions that used fairly reliable sources of information and processed data with relevant logic and deduction.

Example trajectories

A. Flat mind map illustrating result

This example is from a group of students searching for a solution for the following task:

There are a lot of national parks in Canada. A railway was built across the national park shown in the pictures. In this park you can find Hotel Banff Springs. In addition, here is the Kicking Horse Pass. The three highest peaks in the park are Mount Robons, Castle Mountain and Mount Victoria.
1. Which national park is it? 2. What are the heights of these peaks? 3. How long has this park been part of World Heritage?

Here is the mind map of the solution of the task above:

B. Multilayered mind map illustrating trajectory of result

> " I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth."
>
> John Fitzgerald Kennedy

	A	B	C	D	E	F	G	H	I	J	
1	N		U		T		A				1
2			A		G			L			2
3		Y	T			T	O		E		3
4	E				M	E	T		N		4
5			N				I	R		B	5
6		O			G	S		L		O	6
7				U	L	L		T	Á		7
8	H	A				I	E	Á			8
9			A	S				Z		Z	9
10	S				S			S			10
	A	B	C	D	E	F	G	H	I	J	

1. In the riddle above you can read a famous quotation if you take steps according to an 'L' shape. When, where and why it was said and who said it?
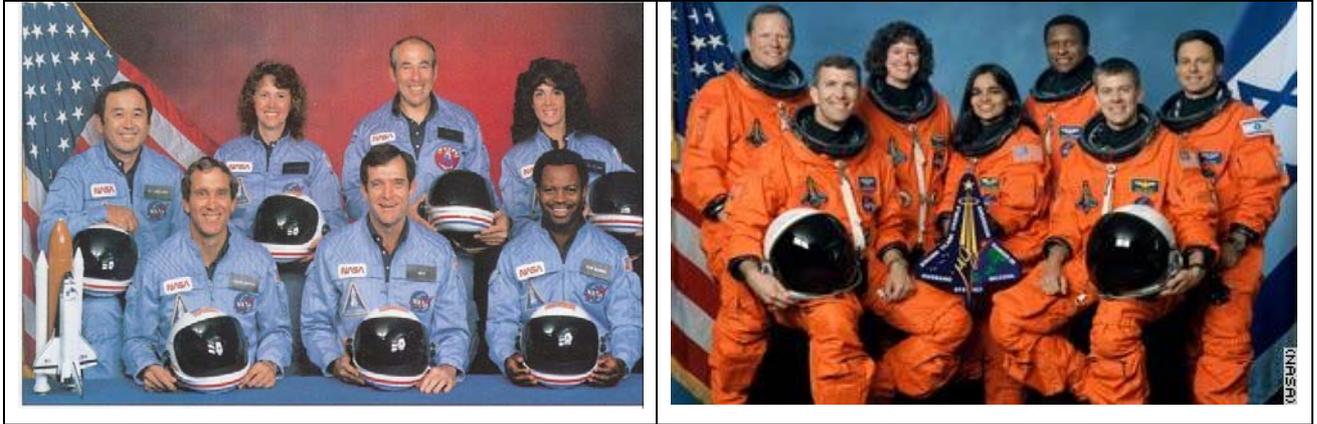
To get the starting coordinates of the riddle, answer the following questions:

Letter: The first letter of an American space shuttle that had the following astronauts: Gus Grissom, Edward White and Roger Chaffee.

Number: The number of letters in the name of the American space shuttle that first docked on MIR space station
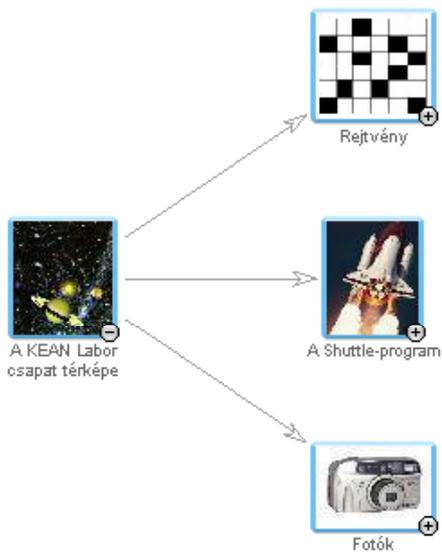
2. What are the names of the American space shuttles born in the Shuttle Program?

3. You can see the crews of two space shuttles. What are names of the two space shuttles and the members of the crews? Why are they "famous"?
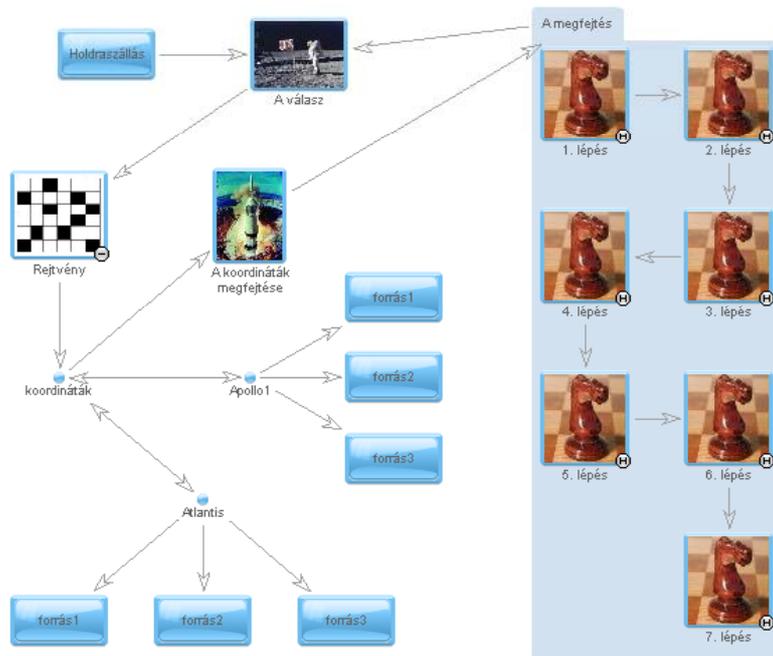

Here is the multilevel mind map of the solution of the task above:

Top level:

Here is the mind map of the solution of the riddle:

The starting point is the checked box. To solve the problem they had to find out the coordinates of the riddle. After getting the needed information for the coordinates (Appolo1 and Atlantis), they could solve the riddle step by step (This is in the pale blue carpet.) The small blue boxes mean the links to the sources of the information. The arrows show the process of the solution.

3.2.6 Evaluation, Results

Learning outcome

We think that the most important advantage of the TeaM Challenge games is that during solving the tasks children obtain problem solving techniques, knowledge needed for handling application programs, searching strategies, skills in recording sources, and their communication skills and logistic skills are developing without them knowing about it. While it was a great pain for students to have to record all sources and the methodology of their solution in the first tournament, it became a usual practice for the second and a natural standard for quoting information in the third tournament.

3.2.7 Conclusion

Mind maps are thus used in tracing the knowledge gained during on and off-computer activities, be that reading text, observations in the real world, reflections or communication of ideas as a tracing tool for thoughts. Mind mapping is a very versatile tool in education that can be used in different ways to enhance the learning process. One of the most effective

ways is to invoke construction of mind maps mirroring internal thought on different topics. Mind maps are an ideal tool for self-expression, communication and collaboration and thus are very efficient tools for collaborative learning.

Experience of TeaM Challenge 2002 (http://kihivas.ini.hu) has proved that 10-14-year-olds can successfully handle this kind of challenge, and solve the problems with much enjoyment and creativity. Besides which they have used all sorts of digital and non-digital sources, including family and acquaintances, in order to solve the complex problems (Kaszas, P., Rethey-Prikkel, B., 2003).

Experience of TeaM Challenge 2003 (http://kihivas2003.neumann-centenarium.hu/) has proved that 10-14-year-olds are able to collect and handle precise links for the digital (internet links) and non-digital (books, CDs, newspaper, brochures, persons they contacted by e-mail, etc.) trails of materials that led to their solutions.

Experience of TeaM Challenge 2004 (http://kihivas.inf.elte.hu/kihivas2004/) has proved that 10-14-year-olds are able to synthesise the precise links for the digital (internet links) and non-digital (books, CDs, newspaper, brochures, persons they contacted by e-mail, etc.) trails of materials that led to their solutions in the form of a mind map using Coraler mapEditor.

3.3 Knowledge maps as navigation maps and tools for knowledge extension

3.3.1 Rationale

Based on Sections 3.1 and 3.2 we further investigate the use of personalised adaptive navigational maps in the form of visual mind maps for children's activities. We wish to find a way to support learners with navigation and help them in broadening their knowledge by extending their own knowledge maps.

3.3.2 Theoretical background

Investigating the effect of using navigation maps without any adaptive support, we find that navigation maps themselves do not necessarily mean help for the navigation problem. It is also claimed that using a navigational map does not really correlate with students' mind maps of the material (Stanton, et al, 2000).

Bookmap Ltd. (http://www.bookmap.com/bookmap_uk.html) claims to have developed a universally applicable method to mimic more efficient organisation of knowledge, which is subsequently combined with specific details that experts consider essential for a good understanding of a complex scientific subject. This combination is used to make the **b**rain-**o**riented **o**rganized **k**nowledge **map** (*bookmap*). When using a *bookmap* the non-expert learner's brain automatically "learns" at the level of the "expert learner", which results in better and faster learning. The report of the SLO (the Netherlands Institute for Curriculum Development) shows that in a field experiment performed on behalf of the Dutch Ministry of Education the school results improved 12% while 34% less time was needed to master the subject (SLO Report).

Besides the lack of personalisation, if we produce web materials for children under 14 years old they would prefer a multilevel navigation map instead of the entire complex structure of the material. Also, it is necessary to use highly visual tools for this age group. Using given trails can help students in recalling information, but they cannot add their own ideas and own experiences to the trail.

"When we navigate through an information ecology, we enact a trail, which can be viewed as a connected sequence of items of information that were encountered during the navigation process. And as we learn, our trails are improved, extended and rearranged. In this sense, ampliative learning consists of trail refinement." (Levene-Peterson, 2002)

Automated log files allow the collection of the trails accessed by learners to be collected and compiled in the form of knowledge maps. We should allow students to edit their own knowledge maps as a combination of these trails, adding their individual mind maps to produce the full complexity of their true knowledge map, as a form of ampliative learning.

The Coraler curriculum map shows the students the material in the form of a mind map that is a multilevel graph, visualizing clearly the logical and content links (see Section 3.2). On the other hand, since a node can also be a file itself, Coraler mapping tool can also be considered as a highly visual file organiser.
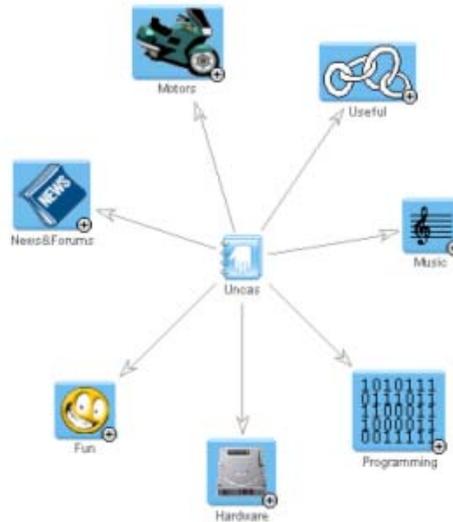
Figure 8. Coraler map of subdirectories of local machine

Taking into consideration the flexibility of the mapEditor, allowing the manual creation of any number of associations between any types of nodes (not necessarily associated with any concrete object, i.e. file or web link) within a map, it can also be considered as an ideal concept mapping tool. The complexity of the map can be detailed to any number of levels, where each level is considered as a group node and clicking on a group node can lead to the level below.

The "*Colabs*" MINERVA project aims to develop an online collaborative learning environment (http://matchsz.inf.elte.hu/Colabs/), which contains Imagine course materials, exercises, tests, asynchronous and synchronous co-laboratories, forums, mailing possibilities, and many more different tools for constructivist learning through collaboration. One such tool being developed is for creating highly visual topic specific mind maps. Tasks include on and off computer activities, which often result in recommending the creation of mind maps on the acquired understanding of a specific topic and/or expression of emotions and other communicative elements. Mind maps are thus used as a tracing "tool for thoughts" in tracing the knowledge gained through off computer activities like reading text, observations in the real world, reflections and communication of idea.

Mind maps can be composed using two tools: the Coraler **mapEditor** for macro constructions and the **Imagine map editor** for micro constructions. Since the nodes of a Coraler map can contain any type of file, it might well even be an Imagine project that contains a mind map itself.

The Coraler mapEditor is thought of as the "big brother" of the Imagine map editor. We wish to create flexible functions for creating similar maps using the features of Imagine, concentrating on visual elements that are closer to children's forms of expression. The following objectives were considered:

- children aged 10-14 should be able to use the tool fluently, like any other computer tool;

- drawing functions present in other software should be used as far as possible, yet the very special abilities of Imagine, as provided in the Imagine environment itself, should also be provided;

- the tool should be enjoyable to use and ease cognitive load – difficult functions that might take away attention from the object of representation should not be used;

- the ability to use multimedia elements: pictures drawn, wave files, different musical elements, animations, web addresses, or even little programs if needed.

3.3.3 Hypothesis

Children 10-14 years old prefer using navigation maps to progress in non-linear project-based learning material.

Concept maps, or mind maps, can be used as learning tools that mirror the knowledge constructed through observation of events or objects in relation to the concepts already known. Different types of computer-based concept mapping tools allow various forms of expression and the versatility of some special tools promote their use from providing course maps for users to providing adaptations of learners' knowledge maps. Modular mind mapping allows a clearer view of more complex structures and the details of endless hierarchies can be embedded. The Coraler mapping tool together with the mind mapping tool developed in Imagine is a modular tool for constructing highly structured maps with flexible content and interpretation for recording digital and non-digital LOs.

3.3.4 Aims of research

The "*Colabs*" MINERVA project (http://matchsz.inf.elte.hu/Colabs) aims to set up an online collaborative learning environment that contains Imagine course materials, exercises, tests, asynchronous and synchronous co-laboratories, forums, mailing possibilities, and many more different tools for constructivist learning through collaboration. Our aims are to provide infrastructure for collaborative work; to provide answers for the guiding research questions: *with whom, how and what kinds of knowledge should children learn at a distance and how*

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best can they be supported in this learning?; and to develop learning tools that are transferable into several domains.

Using the knowledge maps we wish to investigate:

- What the favourite activities are
- Which nodes invoke collaboration
- The validity of the knowledge map
- The clustering of students routes

3.3.5 Frame of research

The Colabs portal is extremely complex; it offers a lot of activities and other enhanced features to the users. So the navigation problem is present. It is not easy for children to find the tasks suitable for their effective progress, even though preliminary written advice to follow specific routes is provided.

As a supplementary project Coraler map is used to trace the students' activities. In this way, the students obtain their project maps, which they can use to easily navigate among the activities and opportunities of the portal.
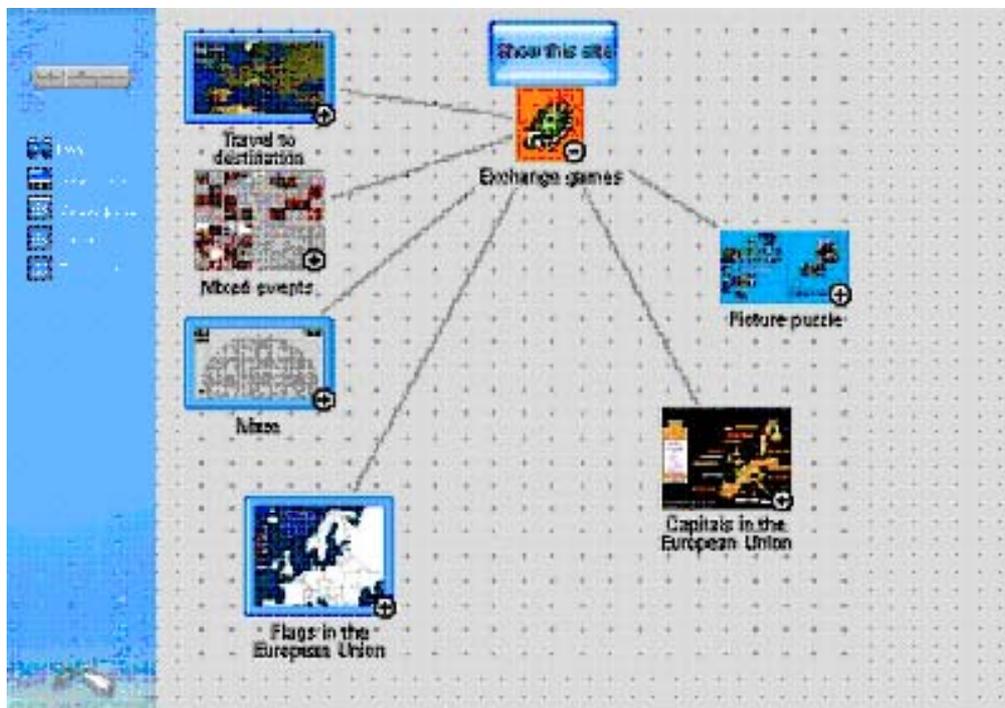

Figure 9. Guiding route map to a specific project within Colabs portal

The Coraler map editor was used to recreate the map of the entire portal. In Figure 9 you can see the submap/subtopic of Exchange games. By clicking on the icons of the Microworlds children can reach the Imagine Microworld and the corresponding forum.

The variety of information that can be mined from the database of the portal allows us to trace children's activities, and we can create their personal map that distinctively shows the visited tasks of the portal.

Using the collected data, individual knowledge maps can be created. These are extended sitemaps that contain the students' accessed trajectories, the time spent on each task, their test results in the Imagine course, their uploaded portfolio (when doing assignments), and their points of collaboration when contributing to Forums.

Individual knowledge maps contain:

- Accessed trajectories
- Time spent on each task
- Test results
- Uploaded portfolio
- Points of collaboration

Using the knowledge map we hope to investigate the following: the favourite activities, the activities that invoke collaboration, the validity of the knowledge map and the clustering of the students' routes.

Finally, we would like to stress the importance of knowledge maps in general. We wish to help newcomers in a highly visual form; we wish to provide students with their personal knowledge map so that they can review their activities and self evaluated their own results; we would like to provide teachers access to students' knowledge maps in order to let them review their progress; and last but not least we would like to provide on-going advice for the students.

Aims:

- To help novice students in a highly visual form
- To provide personal knowledge maps for *students* to review their activities and results
- To provide personal knowledge maps for *teachers* to review the students' activities and results
- To provide on-going advice for students

We also provided an online mentoring service for students if needed. Mentors are assigned to different activities and students can contact mentors when help is needed if they wish. Mentors also monitor activities taking place at their area and try to provide help if they determine a need for it. Mentors also set up new activities and co-laboratories depending on the needs and preferences of users.

3.3.6 Process

1. We first create advisory trajectory maps for children in different learning projects, suggesting routes to take.

2. We log all hits on pages belonging to the *Colabs* network portal and assign logs to the personal profiles of users.

3. Using the data obtained, we create knowledge maps of individuals. These contain accessed trajectories, achieved test results, uploaded portfolio, points of communication and collaboration.

4. Using the obtained data and knowledge maps, we wish to investigate the following:

- What are the favourite activities of users, their achievements and the extent of collaboration that takes place?

- The clustering of student's routes depending on the preliminary advisory trajectory maps taken to examine the typology of users.

- We examine the validity of knowledge maps in mirroring the true knowledge level of students and the ability of maps in providing assistance for teachers to determine points where assistance is needed.

- Evaluation of individual activities online and the achievements attained.

- Analysis of the association of typical clusters with typical achievements to be able to filter successful paths.

- Analysis of portfolio at points of collaboration, to be able to measure the value of collaborative activities.

5. Our aim is to help the orientation of novice students in a highly visual form:

- Personal knowledge maps for students to review their activities and results;

- Personal knowledge maps for teachers to review the students' activities and results;

- Provide continuous support for students.

Results are yet to come.

3.3.7 Conclusion

Even though we are currently in the process of implementing the tools necessary for the system to be fully functional, the preliminary results are very promising. Children seem to feel more secure navigating through the project guide routes and have no problem editing their own knowledge maps in a constructive way.

About Chapter 4

The trails described in Chapters 2 and 3 refer to a specific type of learning, namely formal learning in an educational setting and in a completely digital learning environment. The trails landscape is extended in Chapter 4 to include informal learning in a non-digital learning environment. The specific context that Chapter 4 examines is mobile learning in museums. With learning in museums mobile devices play two roles. Firstly, in as far the mobile device presents the learners with possible routes to follow, they, like the visual map in Chapter 3, serve as a navigational aid. Secondly, they serve to create digital results of a non-digital tour, for example if a learner takes digital notes. They thereby create digital trails, which can be classified as 'result trails' in the sense of Chapter 2.

4   Trails in fieldwork and mobile learning

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4.1 Introduction

This chapter is a selective review of research on the use of mobile learning in two contexts; firstly in museums and related contexts where most of the research concerns informal learning and secondly the use of mobiles for field work in learning Science. However, it aims to inform one particular facet of using mobile devices for learning: personalized learning trails. Peterson and Levene (2003) argue for the importance of providing ways of supporting *navigational* learning, which, they further argue is a particularly important activity in the context of the explosion in ICT and the need to manage and negotiate through vast amounts of information. They give three examples to illustrate what they mean by navigational learning: one is museum based and involves children preparing for visiting a museum, taking notes whilst there and following this up with an assignment; the second is in a professional context of a solicitor re-visiting his past knowledge to update himself and inform his colleagues and the third is a tourist navigating through a city. These examples involve 'trails of learning': a connected series of objects or elements (e.g. the objects in the museum). Two are also examples of what has been described as a 'free-choice learning' activity (Falk & Dierking, cited by Proctor and Tellis, 2003, and Waycott, 2004, forthcoming) whilst the example of the solicitor relates to learning as part of continuous professional development.

Free-choice learning is defined as 'the type of learning guided by a person's needs and interests'.

Peterson and Levene explain that learning trails are 'enacted': the learners engage in experiences whilst undertaking the trails. The activities are sometimes planned in advance and the trails are edited and refined and learners are likely to revisit them. The trails therefore become personal knowledge. They argue that we need to support this aspect of learning: personalized learning trails, and so the question becomes: how can we use technology to help us with the challenges created by technology? The purpose of this section is to review work on the use of mobile devices that is relevant to personalized learning trails and that can inform the development of support for such trails.

Section 4.2 considers what theoretical ideas and/or principles inform the use of personalized trails via mobiles in these contexts. Section 4.3 reviews firstly research on the use of mobiles in museums and related contexts and examples of experimental use in these areas and secondly the use of mobiles for fieldwork in Science and other informal learning of Science and also examples of use in these areas. Although mobile technologies for learning are a very active area, there is still relatively little reported on their use in either of these two contexts. This section therefore focuses on a small number of case studies from the literature and considers them in some depth in order to provide information about some of the requirements for supporting personalized learning trails in mobile learning; the possibilities and lessons learnt. Human computer interaction (HCI) issues such as usability are not the main focus of this review. However, it is necessary to consider them as none of the studies reviewed have used commercially available devices "off-the-shelf", but have needed to develop software for them, and in some cases to develop the devices themselves. In all cases, evaluating users' experience with these devices has raised HCI issues. The fourth and final section discusses the implications of this empirical work for personal learning trails.

4.2 Theory and principles

Levene and Peterson (op. cit.) are concerned with navigational learning, which they view as cycles of planning, enactment and trail editing. Such a cycle can be related to various theoretical accounts of learning such as constructivism and the Kolb (1984) and Dewey (1938/1997) accounts of cycles of experience and reflection.

However, Sharples (2003) has developed a model of learning which is specifically concerned with mobile learning and which is particularly relevant to personalized learning trails for informal learning because of its emphasis on lifelong learning. Because of this emphasis, as discussed and elaborated on below, it is argued that Sharples' model is the most useful for mobile learning. Sharples is concerned to support the kind of informal learning that people engage in a lot of the time and throughout their lives: in pursuing hobbies (such as gardening) or necessary 'life' activities (filling in tax forms) or cooking we spend far more time in such informal learning than we do in 'formal' learning in institutions. Such learning is also genuinely lifelong and highly self motivated. Mobile devices are ideal for supporting such learning as it takes place in different places and users need to be able to take what they have learnt with them and have access to resources in different places. His model of conversational learning is inspired by Pask's work (Pask, 1975) and concerned with such learning outside the classroom and outlines the requirements for devices to support such learning within this model. It is also assumed in this model that learning is social and so the model is concerned with collaborative learning

In designing learning technologies for such lifelong personal learning, he argues that we need a shared language (that includes the computer as well as the learners); a means of capturing and sharing phenomena and a method for expressing and conversing about abstract representations of that phenomena. His theory of personal learning shares a great deal with learning trails:

"We begin with a person engaged with some activity in the world, carrying out an experiment, perhaps, solving a problem or exploring an environment such as a park or a museum. As the person performs the activity he or she tries out new actions, reflects on their consequences and makes decisions about what to do next. The person is actively constructing an understanding of their activities. There is continual interaction and adjustment between the person's thoughts and actions.   Then, in order to gain from that experience, to perform it differently or better in future, the person needs to form a description of themselves and the activities, to explore and extend that description and carry forward the understanding to a future activity… That is the minimum requirement for any person or any system to learn: it must be able to converse with itself about what it knows"
Sharples, 2003, p4.

Sharples sees the technology as providing a 'pervasive conversational learning space': he argues that bringing such technologies into classrooms is disruptive because of pupils' access and links to the outside world but that this can be managed. Existing devices have

not been developed as learning tools and the direction taken by the laboratory that Sharples directs has been to develop handheld devices for personal learning that fulfil a number of requirements that he outlines, including being truly portable, adaptive to an individual's abilities, available anywhere and intuitive to use. They should also be persistent – and by that he means that learners are not constrained by particular hardware but can carry around with them and transfer what they have learnt and their resources from one device to another. Recent developments mean that there are now devices available that although not meeting all of these criteria (notably the challenge of being persistent and usable) are very powerful – and importantly are available fairly cheaply in the shops rather than being a laboratory prototype. So another important research direction is to evaluate how learners are managing with these devices: do they use their functionality? How do they record trails? Partly because mobile devices that combine the functionality of a portable PC with good connectivity are very recent, investigations to date report on the use of devices that have either been developed for the project and are therefore unavailable commercially or have been adapted, for example by adding particular software. This is the case for the literature case studies discussed below.

Finally, Waycott (2004) has taken an Activity Theory approach to researching the use of PDAs for supporting learners (by having some of the coursework on them), and mobile workers. Taking an Activity Theory approach allows her to identify and analyse contradictions and disruptions from using these devices. It also brings into attention how the activities that users engage in change when they adopt new technologies and in turn how the use of the technology is changed and adapted to the activities.

4.3 Investigations of the use of mobiles in museums and related contexts and examples of experimental use in these areas

Research on the use of mobiles in museums and related contexts for free-choice learning has become very busy. It includes the use of mobiles to enhance access to information and use by tourists or visitors to particular cultural events or works of art. However, there are still relatively few studies of users: this is the focus of this section.

Proctor and Tellis (2003), provide an overview on the use of handhelds in museums in 2003. They note that the use of audio guides in museums has a very long history, and technical developments have led to sophisticated digital devices with tremendous capabilities – e.g. MP3 players which can track and download visitor usage patterns, carry multiple languages

and so on. The use of such devices is therefore currently widespread, with nearly all art museums having audio guides that in many cases are included in the museum price. The main case study that they report on is from the Tate Modern in the UK, which has been conducting studies with the aim of evaluating visitor responses to the technology and to a wide range of approaches to multimedia content design.

The Tate Modern Multimedia Tour Pilot

 The Tate Modern Multimedia Tour Pilot study involved 852 visitors and is 'cutting-edge' in that it was designed to define the limit of the current generation of wireless technology – an ambitious combination of location-based and interactive applications. It used commercially available handheld devices (iPAQs) but additionally made use of wireless technology not available on standard iPAQs at the time[1] and developed content and an interface specifically for the Tate Modern in the form of a multimedia tour.   This pilot study consisted of a 45-minute tour of certain galleries which were equipped with location sensitive devices where visitors could experience audio, video and still images and some interactive applications on the iPAQs. It aimed to test both applications of wireless technology in the gallery and to assess a wide range of approaches to content design. These included:

- **Interactive survey and response** (visitors' opinions of a painting before and after seeing a video of its production)
- **Creative play** – mixing soundtracks to accompany a viewing
- **Location-specific content delivery** – content delivered according to location
- **Visitor tracking** – visitors' locations were relayed to a digital map at the desk
- **Visitor paging**
- **Visitor profiling**
- **E-mail facility** – visitors could e-mail themselves further information on objects and artists on tour

Visitor feedback and results of the pilot

Visitors were enthusiastic, with 70% reporting that it had improved their visit and they saw it as an exciting and inevitable development, although it was noted that visitors with an extensive arts background were less satisfied. The average tour time taken by visitors was 55 minutes. The study was a success in showing how the technology could be implemented and also in indicating the strengths and weaknesses of the handhelds and their content.

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[1] but which may well become available on handhelds in the not too distant future.

Learning trails are concerned with keeping a record of a learner's interactions and in this study 61% of the visitors gave their e-mail addresses in order to use the e-mail feature whereby they could e-mail themselves further information on objects and artists on tour. However, the degree of personalization of the tour was quite constrained in that what was e-mailed was just the standard further information that was available. Waycott (2004) carried out a further small-scale study in the Tate in which 6 participants took part. Two participants were observed (including Waycott) another four informally interviewed. Her approach, as we noted earlier, identifies contradictions in adopting new technologies. In this respect her participants note that it can be awkward carrying the PDA as well as pen and paper – in this context the PDA is not set up for taking the visitor's own notes: as we have noted, the 'e-mail home' facility just sends standard further information. There is an issue here, then, of how and whether these devices can be used alongside other tools when users are really mobile such as when walking around a museum. There have been HCI approaches to solving this through the use of gestures and head movements – but they rely on headphones which would be problematic in this context and could not deliver the visual material used in this study.

Although the visitors were not able to capture their own comments and 'take' on their visit (i.e., a truly personalized learning trail), many of the activities were successful. From the visitors' point of view the three activities listed below were much appreciated:

- **Interactive survey and response** (visitors' opinions of a painting before and after seeing a video of its production)
- **Creative play** – mixing soundtracks to accompany a viewing
- **Location-specific content delivery** – content delivered according to location

Favourite stops featured the following design approaches:

- Audiovisual coherence – e.g., where an audio description of abstract paintings was accompanied by zooming into the details being discussed. This is an example of *location specific content delivery.* Other examples of this that visitors appreciated included audio that provided interviews with artists or sitters and video where visitors gave an opinion of a work before and after watching it being created. It was noted, though that video was sometimes used when audio alone would have worked – and so one lesson was the need for appropriate media. Waycott comments in detail on

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some examples: one where there was the option of viewing footage of the artist creating a painting with his unique method; another which drew the visitor's attention to the detail within a cubist painting and a third where images on the screen and dialogue was used to describe a large installation containing several objects that were ambiguous. She and other visitors who were relatively inexperienced in modern art found this information very helpful but more experienced visitors were less impressed.

- Interactive messages – where visitors had the chance to register their opinions and create soundtracks

Multitasking and tracking different media (looking between screen and artwork) was not a problem as long as the message was well designed and the PDA functioned properly. Visitors looked at objects for longer than they would have otherwise, but it was noted that the multimedia tour, which only covered certain galleries, can take visitors' attention away from other objects not on the tour.

As has already been noted the e-mail facility was found to have limitations in the small case study carried out by Waycott and there is little reference to it in Proctor and Tellis' paper. Proctor & Tellis comment that the text facility had a mixed response. Waycott reports that this function, which allows visitors to communicate with each other, was constrained by there being a limited choice of prepared text as it offered standard options for users to text each other with messages such as 'I am tired/cold/hungry'. This option could certainly have benefited from asking users what they would like to send. As noted earlier, Waycott has applied Activity Theory to her work and in this context she was not clear that there were contradictions on the activity of visiting an art museum that required resolving. As noted earlier the constraints included a novel interface, an awkward way of carrying a new tool, and that it used up hands needed for other activities – writing notes for instance. She also points out the implications of the short time period in which such a device is used for the learning curve required to understand the interface: when the device is only used for 50 minutes or so and is not owned, how to use the interface must become quickly apparent.

Although visitors enjoyed them when they did work, the interactive games and polls did not work well because of technical problems and neither did the peer-to-peer communication.

Turning to technical and interface issues, the wireless network worked very well and was more than adequate; however the processor could not always cope and did not have adequate processing speed and operating system stability for multimedia. Further

challenges included battery life and charging and the weight of the devices. The battery life deteriorated after 1.5 hrs of use and then needed recharging for an hour – this limited the number of visitors that could use it in a day. Fragility was not a problem as the iPAQ was put in a case for protection and this worked – none were broken though several were dropped. Users coped with the screen – and the content was designed for this.

Finally, it was acknowledged that the user interface was problematic and that this new technology requires new functions that are not yet known.

Using handhelds at the Exploratorium

Fleck and colleagues (2002) document the use of portable devices to enhance visitors' experience at the Exploratorium in San Francisco, and have developed systems to capture and record visitors' personal trips to the museum – so in essence this is a way of capturing personal learning trails. One of the interesting facets of this study is that it is geared to the challenges of the Exploratorium – by its nature a very interactive museum, and one that is unstructured. This context led to a principle that any devices that visitors use must not interfere with their ability to explore and interact with the artefacts on show. As we saw, this was an issue for the devices used for the Tate Modern Multimedia Tour Pilot described above, as the handhelds required a certain amount of attention.

The work carried out at the Exploratorium is part of a larger project researching 'nomadic computing systems': ubiquitous systems where people move about and use portable devices to access services and appliances that are integrated. The Exploratorium is a hands-on, boisterous, hard to navigate environment. Whilst other museums may fit this description, arguably any mobile device needs to limit the interference to users' ability to use other resources – their hands, eyes and ears.   The unstructured nature of the environment may also be a challenge for learning – many studies have documented learners' need for structure such as narrative when interacting with resource-based materials (see, for example, the MENO project – Laurillard (1998)).

Fleck et al. (2002) conducted initial studies observing how visitors used the museum and found that their visitors mainly explored and only read labels after their attempts to work out what the exhibit was failed; they spent more time at the exhibit if they had not read the label; they played with the exhibits (especially children) and often used them in unexpected ways and if in groups they would share out roles such as one reading the labels and the other interacting with the object. Such an approach could be largely described as constructivist and fits with the theoretical ethos of personalized learning trails.

An initial prototype guidebook was developed which combined the functions of informing, suggesting and remembering – in order to give visitors additional information to their guidebooks and replace the marginal notes that they made in their books and also provide them with a record in the form of a personal scrapbook on their web. This is carried out through physical hyperlinks. The user picks up an identifier by pointing the device (initially a PDA) at the object of interest and this connects an identifier near or on the object to a sensor on the PDA, which in turn converts the identifier to a URL. In this way the user picks up and records the exhibit's homepage.

Trials suggested, however, that three functions were too much for visitors to manage, as well as interacting with the items on display and also that the PDAs were too large and fragile for the Exploratorium: holding one interfered with interacting with the objects: and as with some visitors to the Tate Modern, they found that there were not enough hands. In addition, too much extra attention was demanded, users were lost in hyper-reality, and the combination of the three functions was too complex – whilst they managed to use the inform and suggest function they never got to the remembering function. The next development focused on just one function – recording the visit.

This was called the Rememberer and
"is intended to aid personal recall, stimulate discussions and other forms of social interaction and support users' research or classroom work. It consists of a 'remember-this' technology with which the user selects objects during their visit; a visit record consisting of a set of web pages; and a physical artefact that reminds the user of the visit and contains a pointer (URL) to the visit record." (Fleck et al., 2002)

The devices containing the technology were mainly small: one was similar to a credit card and another was contained on a watch. Both contained RFID tags, which, when within a short distance of a reader on an object, registers the exhibit and lights up an LED to let the user know it has been captured. Jonarda PDAs were also used and allowed a higher number of exhibits to be recorded – but were heavier and larger. The visit record contains the list of exhibit names in the order visited and pointers to the content (usually web addressed). Many exhibits also have cameras and photographs were taken when the exhibit was visited, which could be accessed later.

Before starting the visit users visited a base station exhibit and this assigned them a pseudonym and created and displayed the beginning of the visit record, including pictures of

the user visiting the base station. This also gave them some hands on practice in using the device. 37 individuals and/or family groups were observed and interviewed using the device. Generally the users were positive. They liked the photographs but the images were blurred and of low resolution and users wanted more control over taking the pictures (the pictures were taken automatically when their devices were pointed at the exhibits). The RFID tags were easier than the PDAs. Most users revisited the pages and made and saved comments.

Peterson and Levene (op. cit.) discuss different ways in which navigational learning can be supported. One way is for the system to provide guidance about which trails the learner should follow. A second is a more 'intelligent' approach whereby the system learns the user's preferences from actions over time and can provide more accurate and personalized access to hypertexts. Finally the system can allow ways for the learner to conceptualise and represent trails. This third form of support is exemplified by the Rememberer project described above. In particular, as we have seen, it involves an experience recorder and a lightweight device (as suggested by Peterson and Levene) that can detect a landmark e.g. an exhibit. At this point the recorder can interact with the landmark to:

1. download an image of the exhibit
2. download a link – e.g., to a URL
3. take picture of the user interacting with the exhibit

It could also record the user's voice, although this is not a facility in Rememberer. These recordings provide a trail record accessible from a URL.

4.4 Investigations of the use of mobiles for fieldwork in Science and other informal learning of Science and examples of use in these areas

Reiger and Gay's work (1997) on the use of mobiles for field studies pre-dates the more widespread availability of wireless devices affording good communication and with the functionality of small PCs. They are concerned to support fieldwork in Science with mobile devices, by teaching in authentic and engaging ways, particularly through learning in the context of use. Although contextualized learning has been the subject of debate for some time, recent generations of mobile devices support learning in context in a way that has not hitherto been possible. Reiger and Gay's approach is also consistent with suggestions in the literature that science teachers should engage students in real life problems and promote collaboration. Their work addresses the following research questions (among others):

1. How can mobile devices enhance field laboratory experiments?
2. How can mobile computers enhance learning about science investigation processes (e.g. data gathering and analyses)?
3. What features should mobile computer systems provide?
4. How do students with varying levels of experience use the devices?

They report on two pilot projects developed at research sites near Cornell University (where the researchers are based): the Cornell plantation. In the first project, called 'Cornucopia' the learners were students who are enrolled on an undergraduate genetics course – 'formal learners' learning through an institution.   The application which students used on the mobile devices provided them with a searchable interface to access relevant genetic information about corn: e.g. corn genotype and phenotype and geographical information. Important concepts in plant genetics and evolution were demonstrated by access to digital images of variety traits, genetic models, cross sections and simulations of generations of selections from the field. A week before the first outdoor field study the instructor explained the exercises to the class and demonstrated the hardware that they would be using. The students then carried out their work at the Test Plot a week later using mobile computers, an eProbe data collection instrument and a memory device to insert into the portable which contained the database and was also used for data entry and simple data analysis of ten varieties of corn. This data was then transferred to a laptop for more sophisticated analysis. In their evaluation, students and their instructors expressed high levels of interest and enthusiasm and made suggestions for further developing such work, such as how it could make use of other databases and websites.

The second pilot study, Plantations Pathfinder, supplied information and provided a collaboration space for visitors through an interactive tour – so is close to the kinds of use that we have seen above in museums. Indeed, the Plantation is described as a living museum which is constantly changing. So, as with other museums, an electronic guide can be kept updated more readily than printed material and can keep a record of the visitors' interests and collect information for them to take home, such as through printing out their 'journal' when they return to the visitor centre. This pilot then, is akin to a 'light touch' personal trail.

Before visiting the Plantation, visitors logged on from the desktop to the Plantation web site, where they accessed the interactive tour that they would use on their handheld computer. At the website, visitors could receive more information about a particular garden and search a multimedia database of plants at the Plantation. At the Plantation itself, visitors used the

Pathfinder handheld device (borrowed from the visitor centre) whilst touring the garden and this could provide additional information, e.g. about historic varieties of squash. They could also add entries to a personal journal and make notes for uploading later and search and view the comments of previous visitors. This system does not appear to have been evaluated with visitors using it as such, but it has been demonstrated to potential visitors.

In their conclusions Reiger and Gay point out that the use of such devices should not lead to the neglect of traditional resources that can be accessed from the field and suggest that the design of templates and mechanisms for incorporating other databases will be important areas of future research.

Research at the University of Kent at Canterbury is developing software tools for the mobile fieldworker that can be used with existing handheld computers and sensor technology. In particular they have investigated the requirements of ethology fieldworkers for using PDAs in the field. They define the requirements of mobile computer usage for fieldwork as follows:

1. Dynamic user configuration: the fieldworker will need to collect data during observations and may be lying down, standing or walking.
2. Limited attention capacity: the fieldworker's attention must be on his or her subject(s), which in the case of animals and birds are also likely to be moving. Some observations are 'snap-shot' observations but others are over a longer period of time, over which the fieldworker must observe their subject constantly. Attention therefore must be on the subject and not on using the mobile device.
3. High speed interaction: some subjects have intense periods of activity and at these times the fieldworker needs to enter high volumes of data quickly and accurately.
4. Context dependency: location is particularly important and will need to be recorded: in many cases this might require plotting observations on to a map.

Pascoe, Ryan and Morse (2000) describe a giraffe behavioural study which strongly exhibits these requirements – but they acknowledge that their importance and strength other kinds of field work (e.g. archaeological) will vary. In terms of existing hardware, various features have been evaluated for their suitability for fieldwork.   Five features are considered necessary for fieldwork: a pen-like user interface that can be used on a pad-like device and can be held in one hand to view data and be operated with one hand along with some form of handwritten recognition; (this is a natural substitute for the notebook) and suitable for mobile use e.g. when walking; a small device that can fit into a trouser pocket – as the fieldworker may already have a variety of equipment to carry; long battery life (use for a whole day without replacing batteries) and robustness and finally connectivity so that the data can be

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downloaded. This study predated the widespread availability of wireless devices, and it would be reasonable to update this requirement to include wireless communication and perhaps GPS. Interestingly, most of these requirements are the same as those needed in a museum.

Based on these requirements a number of prototypes were developed which took the form of three prototype programs based around the 'stick-e note' metaphor, where notes are seen as being attached to a context. The authors give the example of a description of a shard of Roman pottery that could be tagged to the location of the find –using these devices fieldworkers can record quite elaborate datasets such as behavioural descriptions. The stick-e notes used in this research could be used as both data and context (because of the self-describing contextual nature of field observations). The three programs are: StickePlates (for recording observations as standard sets of data); StickePad (where the user can create new notes based on templates or edit existing templates – these are likely to be used the most) and StickeMap (where a screen map is provided to offer a different method of representation and icons denoting notes are overlaid onto the map and can be selected to view or edit their contents). The software did not incorporate a new interface design but was set within a familiar interface metaphor – where the fieldworker could quickly learn to use the device confidently.

These programs have been tested in a number of environments, including a two-month behavioural study of giraffe in Kenya in which an ecologist agreed to replace her paper notebook with the prototype for the two-month period of her fieldwork. The ecologist was able to learn to use the system on the flight from England to Kenya and once in the field created templates to record data for observations including vegetation surveys, behavioural observation and giraffe faeces records. In general the prototype allowed the fieldworker to complete more work, and in less time, than would have been possible manually. The HCI factors in the prototype are two general principles:

Indirect Operation – providing interface mechanisms that minimize the amount of user-attention.
This combines the requirements noted earlier of dynamic user configuration and limited attention capacity: in the Kenyan giraffe study the ecologist was able to move around to follow the giraffes and record the data using one hand (the other might be on a telescope, for example).

Context-Awareness – giving the device the capability to sense its environment.

The programs used recorded both time and place using an attached GPS system. If a time or place was not entered into the data, the default was the time and place recorded by the system. Pascoe et al. point out that a range of information could be delivered via this facility of context awareness.

4.5 Discussion and implications for personal learning trails

Learners occupy a central role in each of theoretical approaches discussed at the beginning of the paper. Additionally, Sharples' model has a particularly social perspective, as does Activity Theory that also provides a focus on how adoption of any new technology affects and changes the learner's activities, and likewise the activities for which technologies are used have an impact on how the device is used and adopted.

Looking at the two museum examples it seems that the adapted devices and software (i.e., those specifically geared to the needs of the situation) performed rather better: at the Tate, the standard PDAs were too heavy, awkward to carry, had a battery that ran out and a processor that was not up to the job required. They also required too many resources: they needed two hands and at times visitors' attention was focused on the device rather than what they were interacting with.   Robustness, however, was not an issue once the device was in its case. PDAs were also explored at the Exploratorium, but abandoned in favour of smaller devices that worked better. For use in these contexts, then, it appears to be important that the device does not demand too much of the user's attention and resources and is small enough to be comfortable and unobtrusive.

One general issue of relevance to trails is the question of how multipurpose the device is and what activity or activities it is intended to replace. If notebooks are usually used, the mobile device must either allow this or be small enough to allow a traditional notebook to be used alongside it.   In museums, visitors often take notes or annotate the guidebook and this is an important aspect of learning trails; however, in neither study was the handheld designed to allow visitors to take notes. For visitors to the Tate Modern this meant an awkward shuffling between the PDA and a notebook and at times the PDA got dropped or its stylus lost in the process. The problem did not occur at the Exploratorium as the device was designed with the principle in mind that it should demand limited attention – very small badge like devices were used that fulfilled this criterion. These devices did not allow visitors to record notes-but neither did they inhibit the use of traditional notebooks. In the Plantations Pathfinder study, visitors could take notes on the mobile. In the other studies, visitors could either not easily make their own notes (as in the Tate Modern, where they were e-mailed standard

information) or, in the case of Rememberer they could only do this once they accessed the URL that formed their personal scrapbook after leaving the museum. Yet if learning in context is to be taken seriously, visitors need to be able to make notes and personalize their learning as they are going about their visit, as well as edit them and change them afterwards.

The fieldwork studies had some similarities and some differences. Again particular content and interfaces were developed in both cases, but Pascoe's study, where the device was used by a fieldworker carrying out their professional job, demanded a device and an interface that could not only easily be used with one hand but that could also be used to record data at high speed and with accuracy. This requirement was not present in any of the other contexts. Indeed, in some ways Reiger and Gay's work shares more with the museum contexts – and as many museums are now 'living' museums with outdoor spaces and activities and engage users in experimental tasks it is likely that boundaries between such museums and doing field work as a learner will increasingly diminish. In terms of learning trails, the visitors to the Plantation were able to develop a journal that could be printed out.

Of the 4 requirements of mobile computing for fieldwork outlined by Pascoe, three are shared with museums:
1. Dynamic user configuration: the fieldworker is in different positions and may be mobile.
2. Limited attention capacity: this term (used by Pascoe) refers to the context of the fieldworker whose attention must be on his or her subject(s), and not on using the mobile device. The user must therefore be able to use the mobile device with only limited attention. The same point has been made about mobile entertainment devices – the person using one of these whilst walking or running needs to be able to change tracks or radio stations without having to get the device out of their pocket or off their belts.
3. Context dependency: as outlined above, this means that the device has some 'knowledge' about its environment – for example, this would include knowing its location.

The same technical issues applied in both contexts: size, weight and battery life. In the Pascoe example though the device's function is very clearly to replace the pocket book, rather than being used alongside. So although it is important that the device is small enough to fit into a pocket, it is unlikely that a badge size device such as that used in the Exploratorium would suffice. This study was also different in that the user was a professional carrying out their job. There is therefore a very clear set of activities that the fieldworker

needs to perform with the device and the software is designed to do that through the development of the programs with the stick-e note metaphor. The resulting two principles noted by Pascoe were an interface mechanism that minimized attention requirements and context awareness.

Some final general points:

- All the uses trialled needed some software and sometimes hardware development – there was no off-the-shelf use and shared technical issues – weight, size and battery life. In Pascoe's study a standard device sufficed; for the Exploratorium study, they felt they had to have a small badge size device.

- The device must either work alongside other tools (like a notebook) or encompass its functions completely.

- The issue of how much attention is needed for the device is crucial – and could increase with recording trail information.

- What is needed in terms of trail information will depend on the context. All the museum examples had very positive aspects: the software and devices developed for the Remember project allowed visitors to take photos, capture further information via links to web sites and add comments later; the Plantation did some of this and allowed comments at the time.

- Revisiting had not been considered. However, storing via a website would allow later downloading and changing.

- Context awareness is crucial.

- HCI issues are also crucial and we have touched on some of these above. For example, in museum contexts, there is still considerable debate about the benefits of headsets. Visitors show preference for both options in different studies. One objection to current headsets is their potential to affect the social aspect of a museum visit – they can isolate visitors who are sociable when visiting museums in groups and as we have noted this is an important part of museum visiting. Recent research at Parc, however, suggested that audio was preferred to text, as visitors could stay focused on the display (Woodruff et al. 2001). There is an active line of HCI research on providing alternative interfaces to devices that are used by truly mobile users (e.g. MP3 players) that do not require their visual attention, such as gestures and head movements. However, these would not be helpful where visual information is presented – as in the Tate Modern pilot study.

About Chapter 5

In Chapter 2 a distinction was made between trails that consists of (i) visits to pre-fabricated learning objects (ii) results created by the learner and (ii) discussion messages. Chapter 3 focused on visits to pre-fabricated learning objects, by showing how visited and non-visited learning objects can be presented to the learner in a visual map, which can be used as a navigational aid. Chapter 4 focused on 'result trails', where a tour through the non-digital learning objects in a museum is captured in digital trail of e.g. digital notes to these objects. Chapter 5 focuses on the third type of trail, trails that consist of discussion messages. Chapter 5 shows how trails through discussions can be classified and visualized so as to aid the teacher and learner alike in reflecting on the discussion and on the contributions of particular individuals. This is done by adding several types of metadata to the discussion messages that make up a trail.

5   Trails in computer conferencing

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5.1 Introduction

This chapter will present how examination of the nature of student contributions in a computer conferencing environment may help in supporting students' learning. It is well known from the related literature that students sometimes find it difficult manage and negotiate their way through vast amounts of information presented to them in technology-mediated environments (Peterson and Levene, 2003). Understanding how students make use of the conferencing environment may make it possible to provide better organisation and structuring of conferencing tools.

Visualising interaction patterns in a computer conferencing environment is helpful for improving teaching-learning activities. It also facilitates knowledge management. For example, by knowing students' participation rates, the skills being employed by students when performing tasks and how interactive the students' messages are instructors/mediators will be in a better position to improve their online conferencing strategies.

There is also the possibility that by presenting learners with a visual representation of the relationships between messages when revisiting a discussion, the computer conferencing system will afford a more coherent discussion because it relieves students of part of their cognitive load (Kear, 2001). The information presented to users can be crucial if the users are looking for a suitable community to share their knowledge or to locate experts.

The collection of students' postings to a computer conference contains a record of shared knowledge and also implicit information about participants' behaviour patterns during the discussion (Zhu, 2002). A graphical representation of this content and behaviour may provide us with a better understanding of the conferencing process and allows us to follow students' learning trails.

One of the techniques applied during analysis of these contributions is content analysis, a technique that typically involves comparing, contrasting, and categorising a set of data and can involve both numeric and interpretative data analyses. A detailed content analysis may lead to a collection of links from messages to their respondents.

In the following sections we first present content analysis of computer conferencing in two graduate courses, with a view to investigate the patterns of participation of students and tutors, the content of the messages and the extent to which they formed an academic debate. In the case study we will examine how computer conferencing data can be analysed and/or presented to provide information on students interaction and can be an example of a learning trail.

5.2 Analysing computer conferencing

This section presents evaluation case studies of computer conferencing in a Master's level course in the Science faculty and a fourth level social history course in the Arts faculty at the Open University, UK. In both courses, conferencing is the primary medium for discussing academic issues and getting feedback. In the Science course it is also a forum to discuss more general relevant issues, and in the social history course it effectively replaces face-to-face tutorials. For the purposes of this study we will only focus on the analysis of conferencing contributions by students (see Jones, Scanlon and Blake (2000) for more information).

In both courses, conferencing contributions were analysed in two different ways. The number of messages and their length were recorded and also whether they were from

students or tutors (in order to investigate the pattern of interaction). The content of the messages was also scrutinised in order to investigate how students answered the questions posed and the extent to which they referred to other messages. Each student message in the selected conferences was categorised, and the categories were derived using a grounded theory approach (Strauss, 1987). Although this conference is for academic discussion, some messages related to social or other aspects of the course. We chose to focus on only the messages related to academic discussion, so not all the messages in the conference are included in the analysis.

The categories derived are given below:

- supports answer with references
- supports answer with argument
- adds new dimension/question
- acknowledges one or more other contributions
- provides/seeks clarification
- agrees with other contributors
- peripheral inquiry/reply
- has reservations/disagrees with another contribution

These categories are not exclusive. Together they provide some evidence about the extent to which the contributions fulfil two of the main criteria that we might expect of such an academic conference:

a. a contribution to academic debate and
b. collaboration

These categories were also used as a starting point in analysing the contributions in the Science course. Clearly, although we are aware of the limitations of making such a comparison, using the same categories would be helpful in highlighting any similarities and differences in the two courses. In the end, the resulting categories for the Science course were slightly different then the Arts course due to the nature of the topics discussed. Students in the Science course decided themselves and discussed a particular scientific controversy: genetically modified organisms and nuclear waste disposal.

The categories for the Science course were:
- supports answer with references
- agrees/acknowledges others
- adds new dimension/question

- has reservations/disagrees with another contribution
- provides/seeks clarification
- peripheral inquiry/reply
- reasons for controversy
- solutions to controversy

When compared to categories used for the Arts course we can see that the following categories were retained unchanged: *supports answer with references; adds new dimension/question; has reservations/disagrees with another contribution.* The categories *acknowledges one or more other contributions* and *agrees with other contributors* were combined to form one new category, and two additional categories that reflected the content of the Science communication conference were introduced. These were *reasons for controversy* and *solutions to controversy.*

This type of analysis provides us with an understanding of what kinds of information are exchanged among students, in other words what kind of information they think is useful for their study. When we examine the percentages of student contributions for comparable categories in the two courses we see that *supporting the contribution with references* was the largest category (40%) in the Arts course whereas in the Science course *reasons for controversy* and *solutions to controversy* together formed the largest category (50%). The degree of peer collaboration, as indicated by acknowledging and referring to other students' contributions, also differed in the two groups.

Categories in the Science course	% of category		Categories in the Arts course	% of category
supports message with references	7		supports answer with references	40
agrees with others	9		agrees/acknowledges others	2
adds new info/poses questions	14		adds new dimension/question	14
reasons for controversy	31		supports answer with argument	14
solutions to controversy	19		disagrees/have reservations	0
acknowledges one or more others	17		peripheral inquiry/reply	12
disagrees with others	13		provides/seeks clarification	17

For both courses, the content (and form) of the discussion in the academic conferences was tightly structured (and somewhat similar) so that students, were, in effect, debating particular questions and sub-questions. The analysis of conferencing contributions by categorising them can help instructional designers to find about the effectiveness of computer conferencing and improve techniques used. In addition, engaging in comparison of different experiences should help us to continue to clarify whether and how conferencing is changing the experience of study within disciplines.

In the following case study we present a slightly different type of content analysis applied to a computer conferencing activity in an undergraduate course in computing.

5.3 The case study

5.3.1 Task

The context for the case study is a small-group collaborative assignment in an Open University course on computing. One of the learning outcomes of the course is collaborative working, seen as an essential part of today's software engineering profession. The collaborative working on the course spans four group projects. The project we consider in this study focuses on issues of *object-oriented analysis* in the development of software systems. The nature of the task is such that students' collaboration is required both for the interpretation of the problem (determination of user requirements) and the application of appropriate techniques for its solution (a system design). Therefore the project task is of a

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problem – solving nature, requiring students to apply software-engineering skills acquired on the course to a novel problem.

5.3.2 Analysis

An investigation of the interaction patterns and nature of the content of the messages that were sent to the group-work conference was carried out (for more details see Blake and Rapanotti, 2001). The content analysis resulted in a contribution table showing:

- unique contribution label,
- number of the message in which the contribution appears,
- identifier of the message sender,
- list of messages expressing disagreement with the contribution,
- list of messages expressing agreement with the contribution, and
- content of the contribution in the context of the project task.

This table led to a content-dependent representation of the conference interactions in the form of a directed graph (see Figure 10).
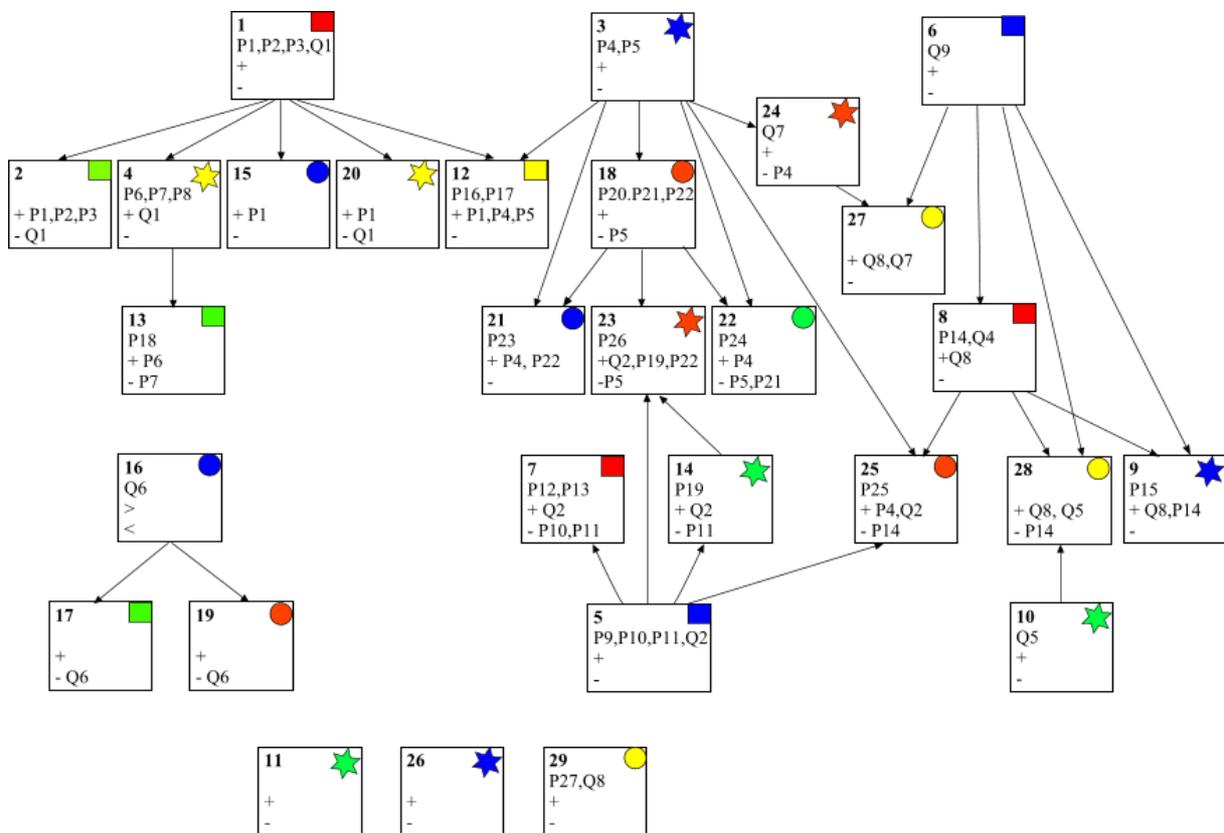

Figure 10. Conference interaction map

Each node of the graph is annotated to indicate:
- Time progression: nodes are ordered chronologically, based on the message timestamps;
- Sender identity: coloured shapes within nodes are used to identify messages from the same participant;
- *Propositions* and *queries*: each node is annotated with a list of the labels indicating the contributions included in the message. *Propositions* represent students suggested solutions for particular aspects of the system design. For example suggesting that a software component (e.g. a class of objects) should be included in the system design. Queries, on the other hand, represent dialogue extension questions on aspects of the system design, i.e. they are statements in which students express uncertainty and invite further comments;
- Agreement and disagreement: each node shows whether the message includes agreement (+) or disagreement (-) with earlier contributions.

As well as providing a succinct summary of the conference, this pictorial representation can be used to retrieve:
- Clusters and trails of discussion: by looking at the way nodes are related through arrows it is easy to identify messages that contribute to the same discussion. Also, node annotation allows one to navigate each trail within the discussion;
- Influential contributions: by looking at the descendants of each node (i.e. the nodes at the end of arrows departing from the same node) and their annotations, it is possible to identify those contributions that generate large numbers of responses from conference participants;
- Level of students' participation: as nodes are colour-coded to identify message senders, it is easy to establish how wide and influential each student's participation is to the conference.

This type of analysis of computer conferencing contributions helps to gather evidence of collaborative learning in an objective way. It is possible to document students' actions such as asking questions, forming hypotheses, providing evidence against and for the hypotheses proposed, providing and sharing information and commenting on contributions from fellow students.

Other researchers have carried out similar work "to capture the interactive process in online discussion" (Hara, Bonk and Angeli, 1998; Howell-Richardson and Mellar, 1996). The study by Hara et al. revealed several unique patterns of interaction, such as "starter-centred", "scattered", "synergistic" and "explicit" interaction.

There are also studies investigating ways of conveying information about participants to each other in online environments. Xiong and Donath (1999) for example offer data portraits, i.e. abstract representations of users' interaction history. The main aim in this type of approach is to convey a sense of the participants' identities and behaviours and to show the ebb and flow of conversational activity (Donath, Karahalios, Viegas, 1999).

The visual representation of interactions can be crucial in evaluating teaching and learning situations.

These visualisations can also be used to inform participants in an online environment about other participants. This kind of holistic knowledge of an online environment can only be achieved after substantial participation in the group. If these visualisations can be introduced to online communities it may help to enhance users' understanding of the social context.

6   Working with trails: a collaborative case study, using the IMS-LD approach

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6.1   Introduction

Our objectives within a regional two years project [Modèle de Scénarios pour la classe] between two research teams (ARCADE in Grenoble and Syscom in Chambéry) are to help teachers who will use a Learning Management System (LMS) to build learning activities including some collaborative work.

Our proposal within this project was to use a down-top process in order to formalize the various steps that teachers will make from a didactical scenario that is captured in a narrative to a computable scenario that will be delivered by a LMS.

This work has much to do with trails because the kind of scenario we try to design in a formal way can be seen as "planned trails" through digital LOs, which will produce effected trails. Effected trails will be displayed to learners through interfaces to support their activities during learning; teachers or researchers in educational sciences will also record them in order to allow analysis.

The first part of this paper presents the different steps of IMS-LD formalization of the scenario, and later we describe where trails are considered.

Because we do not want to entirely describe the IMS-LD's terms and models, we will progressively introduce the major useful elements with a short description before listing which of them are required in our study.

6.2 Formalization of a case study

6.2.1 Narrative: Step 9 of "La fée carabine"

We start from a role-play scenario entitled "Welcome to the *Terres Lointaines* Publishing Company", which is used by French teachers of literature working in an open secondary school dedicated to young high level sportsmen or young patients, who need remote learning activities. The role-play involves a committee that has to take a decision about publishing a novel "la fée carabine" from Daniel Pennac. The scenario is given in a textual form: "*Reading committee of Terres Lointaines publishing company*", that gives several roles to the students and they have to play them through ten steps. We focused especially on one step of the narrative, step nine, because of its collaborative approach.

The Committee gathers to decide whether or not to publish « La fée carabine ». Many agree but someone interrupts the debate, raising one hand. It is a young lady who says: « I find very upsetting that "Mo le Mossi" and "Simon" are killing "Risson" by overdose. They are not entitled to dispense justice! ». She is talking about chapter 32. A rustle goes through the assembly. The reactions are immediate, but what do you think about it? The committee's director looks at his watch and decides to debate in a convenient place - "The Local Pub".

Objective: Take position in a debate

Proceedings:

Pupils are invited to read chapter 32, after which they all access a forum named "The Local Pub". The teacher assigns a pupil to be the reporter of the debate and all must give an opinion and advance a new argument about what "Mo" and "Simon" could do. After 20 minutes, the reporter will draw up a synthesis of the different ideas and reactions and set up the group position on whether or not to edit this chapter.

Note that every pupil has to intervene at least twice in the debate.

6.2.2 Methodology

We define this step nine as a ***complete unit of learning*** (as defined by Koper (2002): a course, a module, a lesson, a sequence of activities).
ARCADE's part of the work was to cast the narrative form of the scenario into a formal model using abstract terms (and classes) that are described in the IMS-LD specification.

In accordance with IMS-LD, we followed the incremental process described in the IMS-LD Best Practice and Implementation Guide:

From the narrative, we captured which roles are involved, which resources (LOs or tools or services that are parts of the "environment" in IMS-LD) are necessary, determined links between roles, environments and tasks (activities), taking account of the interactions between each of them (and also between user and system) and organized each part of the scenario with respect to chronology and knowledge or competency acquisition as described in the narrative.

To illustrate the results of this analysis, we drew a UML activity diagram, that is an intermediary step, used to depict a workflow and parallel process.

On the basis of this UML activity diagram, we set off one XML document instance of the "Unit of Learning: step 9" that conforms to the IMS-LD specification.

The XML description resulting from our work then has to be interpreted (SYSCOM's part of the work) with another model, "Modèle de participation" that is underlying the "Electronic Schoolbag" platform's organization. The final goal was to make it compatible with its APIs, to lead to a deliverable Learning Unit.

6.2.3 Designing with IMS-LD

In accordance with IMS-LD specification, step 9 is considered as a complete *unit of learning*. The core of a unit of learning is called method, specifying the dynamic aspects of the learning design.
"The method is designed to meet learning objectives (specification of the outcomes for learners), and presupposes certain prerequisites (specification of the entry level for learners). The method consists of one or more concurrent play(s); a play consists of one or more sequential act(s) and an act is related to one or more concurrent role-part(s), each role-part associates exactly one role with one activity or activity-structure. The teaching-learning

process is modelled in the method on the notion of a theatrical play. A play has acts, and in each act has one or more role-parts. The acts in a play follow each other in a sequence (although more complex sequencing behaviour can take place within an act). The role-parts within an act associate each role with an activity. The activity in turn describes what that role is to do and what environment is available to it within the act. In the analogy, the assigned activity is the equivalent of the script for the part that the role-plays in the act, although less prescriptive. Where there is more than one role-part within an act, these are run in parallel." (IMS-LD Information model)

IMS-LD offers three levels of implementation:

Learning Design Level A includes all the core vocabulary needed to support pedagogical diversity.

Learning Design Level B adds Properties and Conditions to level A, which enable personalization and more elaborate sequencing and interactions based on learner portfolios.

Learning Design Level C adds Notification to level B, which, although a fairly small addition to the specification, adds significantly to the capability, but potentially also to the implementation task where something similar is not already in place.

Because we need to express different rights for pupils, and in order to improve the correspondence between properties of IMS-LD and primitives and awareness policy of the "Electronic Schoolbag", we have chosen a level B implementation.

So, the first step consists of identifying roles, activities to be played by the different roles, environments to be available for each activity and roles properties.

Roles

There are two major types of roles in IMS-LD: *learner* and *staff*. These can be specialized into sub-roles.

In our case study, we can identify two learner roles (committee's member and reporter) and one staff role (the teacher playing the director of the publishing company). A particular fourth role is needed to allow every pupil to be active in the negotiation phase – it is a composite role representing the group of pupils.

R_Director: type ***staff***

R_Reporter: type ***learner***

R_Member: type ***learner***

R_Group: type ***learner***

Simple Activities

The IMS-LD specification provides description of two kinds of activities: learning activities and support activities. A learning activity is directed at attaining a learning objective and is performed by a learner. Even if global objectives or prerequisites are linked to the learning unit, a learning activity has elements to specify its particular objectives or prerequisites.

A support activity is meant to facilitate a role performing one or more learning activities. Staff members typically perform support activities (however, learners can support learners or staff members can support staff members). An optional reference can be set to express which role is supported – in this case it is expected that the support activity will act for every single user in the specified role. Note that no learning objectives or prerequisites are defined with this type of activity.

We can specify when a learning activity is completed (user-choice or time limit at level A, extended with when-property-is-set at level B) and actions that are to be executed on completion of the activity (feedback description at level A, extended with change-property-value at level B).

We display below the different activities that we have identified from the narrative, giving for each of them their type (support or learning), conditions for their completion and what special actions will be done on completion.

Activity Name	Type	Complete-activity	On Completion
SA1_Intoduce	Support	User choice	
LA2_Read_rules	Learning	Time limit: 5 mn	
LA3_Read_chapter	Learning	Time limit: 15 mn	
SA4_Assign_reporter	Support	User choice	P_Reporter = true
SA5_Regulation	Support		
LA6_Give_opinion	Learning	User choice	P_Pos = true
LA7_Advance_Argument	Learning	User choice	P_Arg = true
LA8_Note_interventions	Learning		
LA9_Negociate_synthesis	Learning	Time limit: 10 mn	
LA10_Present_synthesis	Learning	Time limit: 10 mn	

Figure 11. Activities for the case study Step 9

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Structured Activities

Activities can be assembled into activity-structures, which can be associated to a role in a role-part. A structure can model a *sequence* or a *selection* of activities. It is very useful to design a model of the unit where one role has to perform a set of activities while another role performs another set.

Here, we have to let the students choose if they first want to give a new argument or react to an existent one, but we want to ensure that they really do this twice; so we use two structured activities where activities are played in sequence. Each structured activity is then regrouped in another structured one with a selection mode.

GA1_Prepare_debate = {LA2, LA3}, sequence

GA2_DebateAO = {LA6, LA7}, sequence

GA3_Debate OA = {LA7, LA6}, sequence

GA4_Debate = {GA2, GA3}, selection

Properties

Properties can ensure dynamical control of assigned roles and give a way to register what a particular person has done while executing an activity.

Here we have to verify if each student has at least given one opinion and token position on another one. We also need to assign one student to the R_Reporter role during execution of the learning unit.

P_Reporter: boolean (true when a pupil with role R_Member as been assigned to role R_Reporter)

P_Arg: boolean (true when a pupil with role R_Member has contributed to the debate with a new argument)

P_Pos: boolean (true when a pupil with role R_Member has contributed to the debate by giving an opinion)

Environments

Environments are linked to activities by the 'environment-ref' element of its information table. The term environment gathers LOs (i.e., any reproducible and addressable digital or non-digital resource used to perform activities, e.g. text book, web pages, editors, instruments, test items, …) and services (e.g., send-mail, conference, …).

To design the "The Local Pub" forum described in the narrative, we decided to link a forum (asynchronous conference service) with GA4. We assume that proceedings and chapter 32 are delivered by web pages and that the synthesis will be edited with a text editor.

Environment Ref	Type	Nature	Linked to	Content
E_Proceedings	Learning Object	Web page	LA2	proceedings for step 9
E_Chapter32	Learning Object	Web page	LA3	chapter 32
E_Synthesis	Learning Object	document	LA8, LA9, LA10	outcome: debate's synthesis
E_Teditor	Learning Object	Text Editor	LA8, LA9, LA10	
E_Forum	Service	asynchronous conference	GA4	

Figure 12. Environments for the case study Step 9

UML Activity Diagram

Swimlanes are used in this chart to describe which role is responsible of which activity (that determines a role-part in IMS-LD), and strong horizontal lines figure synchronization points in the scenario.
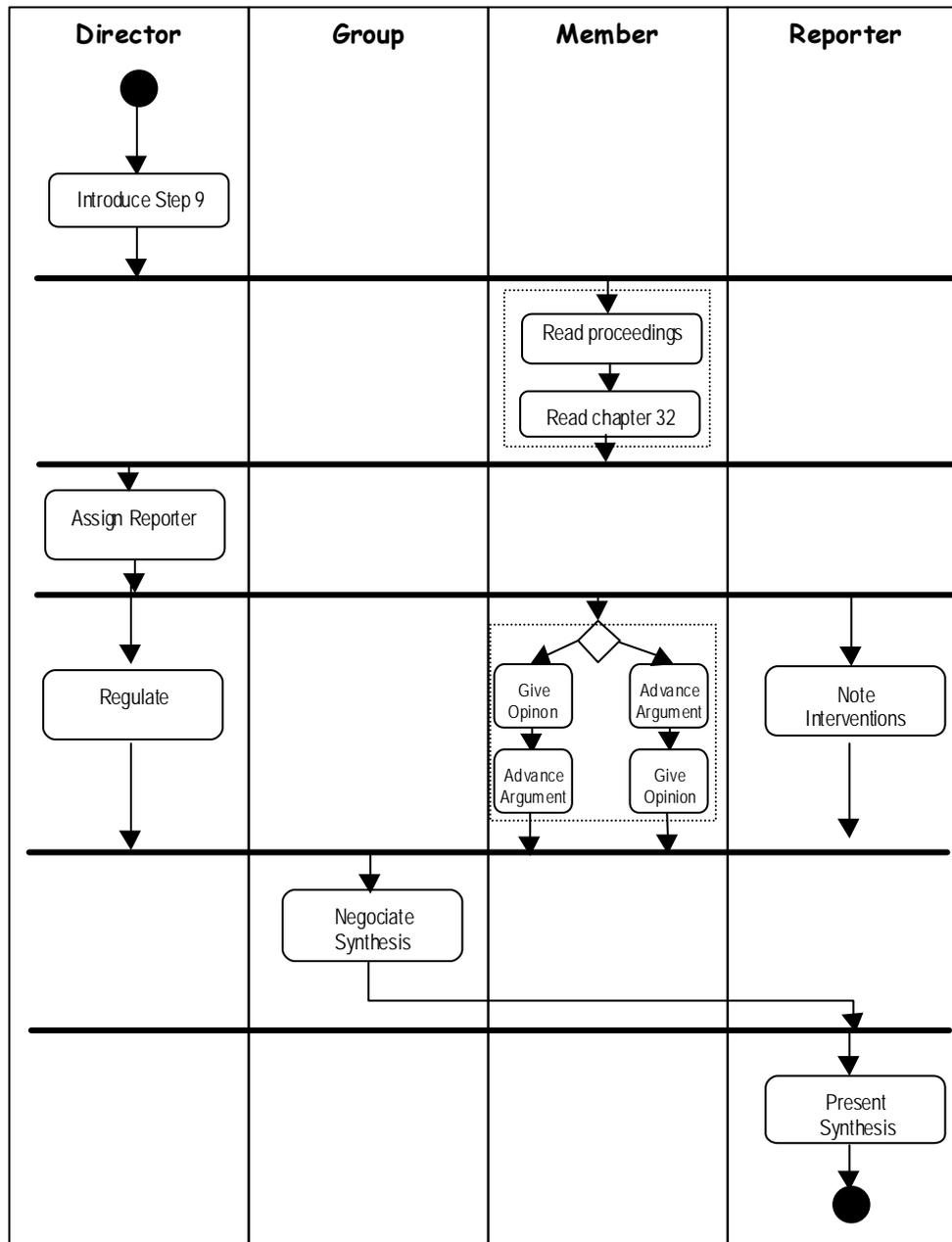

Figure 13. Activity diagram for the case study Step 9

The next step of conception consists of producing an XML document instance. This document is given in the Appendix, but we can show its structure according to IMS-LD specification in a pseudo-language, as in the next section.

Short XML Description

Roles:

R_D   Director (Staff)

R_R   Reporter (Learner)

R_M   Committee Member (Learner)

R_G   Group (all the learners)

Properties

P_Reporter   Role = R_M   Type: Boolean   (True when a learner is assigned as reporter)

P_Arg   Role = R_M   Type: Boolean   (True when a learner advance one argument)

P_Pos   Role = R_M   Type: Boolean   (True when a learner give one opinion)

Activities

Learning Activities

LA2_Read_rules * Environment = {E_Proceedings} * Complete if time = 5'

LA3_Read_chapter * Environment = {E_Chapter32} * Complete if time = 15'

LA6_Give_opinion * Complete on user choice * When completed P_Pos = True

LA7_Advance_argument * Complete on user choice * When completed P_Arg = True

LA8_Note_interventions * Environment= {E_Synthesis,E_Teditor} *Complete on user choice

LA9_Negociate_synthesis * Environment= {E_Synthesis,E_Teditor } * Complete if time = 10'

LA10_Present_synthesis * Environment = {E_ Synthesis,E_Teditor } * Complete if time = 10'

Support activities

SA1_Introduce * Environment = {E_Proceedings} * Complete on user choice

SA2_Assign_reporter * Environment = {E_Synthesis} * Complete on user choice

* When completed P_Reporter = True

SA5_Regulation * Environment = {E_Forum} * Complete on user choice

Structured activities

GA1_ Prepare_Debate * Sequence * Environment = {E_Proceedings} * LA2_Read_rules

* LA3_Read_chapter * Complete on user choice

GA2_ DebateAO * Sequence * Environment = {E_forum} * LA7_Advance_argument

* LA6_Give_opinion * Complete on user choice

GA3_ DebateOA * Sequence * Environment = {E_forum} * LA6_Give_opinion

* LA7_Advance_argument * Complete on user choice

GA4_Debate * Selection * GA2_ DebateAO * GA3_ DebateOA * Complete on user choice

---

Environments

E_Proceedings * Learning object = LO_Proceedings

E_Chaoter32 * Learning object = LO_Chapter32

E_Synthesis * Learning object = LO_Synthesis

E_Forum * Service - Conference = S_Forum

Method

Piece:

    Acts:

        Act1:

            Partition: (Role = R_D , Activity = SA1_ Introduce)

        Act2:

            Partition: (Role = R_M, Activity = GA1_Prepare_debate)

        Act3:

            Partition: (Role = R_G, Activity = SA4_Assign-reporter)

        Act4:

            Partition: (Role = R_D, Activity = SA5_Regulation)

            Partition: (Role = R_M, Activity = GA4_Debate)

            Partition: (Role = R_R, Activity = LA8_NoteInterventions)

            Complete if time = 30' or if for every R_M P_Pos = true and P_Arg = true

        Act5:

            Partition: (Role = R_R, Activity = LA9_Negociate_synthesis)

        Act6:

            Partition: (Role = R_R Activity = LA10_Present_synthesis)

Conditions: /////

6.3 Trails within IMS-LD approach

IMS-LD doesn't use the term of "trails", but we consider that a learning design describes implicitly planned trails or elements necessary for the creation of trails when designing a unit of learning and provides elements that will be registered as effected trails.

6.3.1 Planned trails

The planned route that is described by the UML activity diagram (see Figure 13) is a planned fixed trail. Every person assigned to a specific role in the scenario will follow this route as designed before delivery.

6.3.2 Effected trails

Different elements provide information that can be effected trails during and after execution.

Complete activity, act, play or unit of learning

When the end of one activity, act, play or unit of learning is attempted, the corresponding property is set to true, so that we can store as a *visit trail* the part of the scenario that has been followed by one actor and which part remains to be run.

Outcomes

The synthesis document drawn off the debate by the reporter after negotiation with the group of learners is named *outcome* in IMS-LD. This document is considered as a new LO available to be used by a future activity. Here, outcome becomes a *discussion trail*.

Property values

Another way to observe or register effected trails is to evaluate properties linked to a person or a role within the learning design. Here we know if a student has advanced an opinion in the debate by evaluating the relevant properties. When the teacher assigns one pupil to be the reporter, this pupil gets a new role (in addition to the primary member role), and this is dynamically realised with a special property set to true.

Hence we can consider that the values of these properties belong to effected *visit and results* trails.

6.3.3 Elements necessary for trail creation

In our case study, the unit of learning uses a conference service to ensure all pupils can exchange and debate. This service is a necessary element to track the pupils' interventions and to allow the reporter to build a synthesis outcome, so the conference service belongs to the elements necessary for the creation of trails, but that are not themselves trails.

6.4 Conclusion

Using IMS-LD, we are convinced that we can address a large range of learning approaches while designing learning units.

Inspired by the theatrical metaphor used by IMS-LD, and according to the vocabulary used by our French community, we can speak of learning *scenarios* to describe how the components are linked together and how the different steps (activities) planned in the unit of learning are sequenced.

In the trails group, these scenarios can be seen as planned trails.

It seems to be very important to use an explicit formal description of scenarios in order to ensure reuse, sharing and interoperability. The implementation of such scenarios on a LMS is facilitated by the interoperable XML format. Using the guidelines of this specification allows teachers to describe planned trails and plan what effected trails will be recorded and observed. We assume that the semantics of these effected trails is closely provided by the existence of the scenario so that it may lead to further analysis.

The next step of the project "Modèle de scenarios pour la classe" is to implement the case study in the LMS "electronic schoolbag de Savoie". After an experiment with teachers and students the model will be consolidated, and generic tools for editing and implementing the scenario could be developed.

About Chapter 7

The preceding chapters have described various forms of working with trails. These forms of working with trails would be impossible without some form of collecting data. Personalised learning becomes possible only if data on the learner's level of achievement, the learner's interests, etc. are available. This data in turn might partly be derived from earlier trails that the learner has followed. Data collection is the subject of Chapter 7. Chapter 7 describes the type of data that can be collected, the format that collections have and devices that can be used in collecting the data.

7   Data collection in Trails

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7.1   What is data collection and why is it useful for learners working with trails?

Data collection, in the context of working with trails through digital and non-digital objects, is collection of information before and during individual or collaborative learning activities.

Data collected, relating to individual as well as to collaborative situations or actions, can help learners in tracking and understanding their effected trails, building visual maps and improving learning strategies. It may help to enhance users' understanding of the social context.

On the other hand, learners are likely to revisit trails that become part of their personal knowledge. Therefore data collected during experiences as well as data on the history of the experiences (chronology, association with other events, etc.) should allow the reconstruction of the trail.

7.2 What kind of data can be collected related to trails in collaborative learning contexts?

Data that can be collected for digital objects includes:

- Text
- Interactions (capture of inter-group communication acts)
- Shared activity space actions
- Control actions like key requests (Komis, Avouris and Fidas 2002)
- Session time
- Location (Nova et al. 2004)
- Author identification
- Participation rate
- Results and solutions produced
- …

Data that can be collected for non-digital objects includes:

- Textual description (manual data entry – e.g. personal journal, completed metadata templates)
- Pictures
- Video
- Audio
- Context awareness – data provided by sensors (noise, movement, light, smells, etc.)
- RFID tags
- Position data (using a GPS system)
- …

Various examples of data collection have already been given in earlier chapters. A more complex data collection system might require plotting observations on to a map – for example an object can be tagged to the location of a find, which can enable the recording of elaborate datasets such as behavioural descriptions.

Another example that we saw in Chapter 4 in the use of handheld devices at the Exploratorium, the user could pick up an object identifier by pointing a device at the object of interest. In this way data of the object is collected, recorded in the form of web pages for instance. At the end, the visit record contains the list of exhibit names in the order visited,

pointers to the content and video or picture shots that can be accessed later. The device might also record the user's voice.

7.3 How can data be collected to form personalised trails?

7.3.1 Data collection tools

Data that can be used to form personalised trails can be collected through the use of Data Collection Tools. Here are some examples of tools (software & hardware):

7.3.1.1   Networked and collaborative environments

Networked and collaborative environments are ideal for recording histories of access to digital artefacts and many other online interactions, for example:

- Server log files provide a history of accesses to all resources on a particular server. This data can often be processed to show the sessions of individual users and groups.

- Instant messaging systems allow users to save the conversation at the end of a 'chat' session. The log shows the chronology of interventions and identifies its author.

- Shared Whiteboard logs show (in chronological order) the objects added to the board, identifying form, colour, dimension and position.

- In Video Conferencing systems the whole video session can theoretically be recorded.

- The supervision tool of the ModellingSpace[2] open learning environment allows seeing an overview of the interaction (details, key possession, chat dialog, relations, entities, actions, etc.), a playback of the actions and the possibility of creating snapshots, an event viewer showing all data in a table and an annotated workflow view.

7.3.1.2   Mobile devices and non-digital objects

It seems that there are no commercially available devices and software adapted to the collection of data for personalised learning trails. Existing devices have not been designed for the purpose of recording trails. However, in general, smaller and usable devices seem to be more effective (as was discussed in Chapter 4). Some possibilities for the collection of trail data on mobile devices are:

- Data collected through sensors (via infrared, RDFI, etc.).

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[2] ModellingSpace IST-2000-25385, www.modellingspace.net

- Data collected though user data entry, e.g. a personal journal.

- Automatic data collection such as position (GPS).

- Electronic guides can keep a record of the visitor's interests and collect information for them.

- Eprobe: data collection instrument for fieldwork in Science (as in Chapter 4).

- Stick-e notes: 'StickePlates' for recording observations as standard sets of data, 'StickePads' for the creation and edition of notes based on templates and 'StickeMaps', which provide a different method of representation of the content.

7.3.2 Data collection formats

Data is collected in a certain format, which can then be structured depending on the use needs. Logs are usually recorded in text format (see Figure 14). However, in more sophisticated systems they can include links to screen shots of a whiteboard interaction, simulation application, movies, audio, etc. (see Figure 15).

There are tools (mainly designed for the tutor rather than the researcher), which allow the tracking of different events, following a certain thread of actions and a "multilevel annotation of activity" (Avouris, Komis, Margaritis and Fiotakis 2003).

Figure 14. A text-based log of student interaction from the R2 collaborative concept-mapping environment, from Komis et al. (2002)
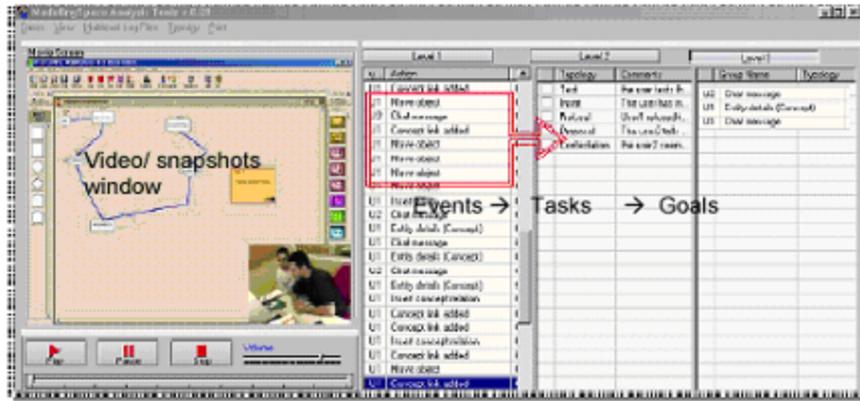
Figure 15. An example log file from the ModellingSpace system, viewed in the "Analysis and Supervision" environment log viewer, which allows playback of the activity from the log file in either a step-by-step or continuous manner

The structure and format of data collected through the use of mobile devices should be portable so that it can easily be transferred to a PC or web server for analysis. In some cases users can have access to recorded data and take them home, such as by printing out their journal when they return to the visitor centre. We can imagine a situation in which recorded data of the users position during his visit of a site (position, notes taken, etc.) is replayed in a 3D and multimedia environment representing the natural settings.

7.4 How can trail data be classified, retrieved and represented?

Content can be analysed by comparing, contrasting and categorizing a set of data and can involve both numeric and interpretative data analysis.

In computer conferencing, detailed content analysis may lead to collection of links from messages to their correspondents. Collected data can then be organised to study interaction patterns. Data can be organised and used to retrieve:

- Clusters and trails of discussion
- Influential contributions
- Level of participation

Knowledge contained in free text and in different languages might also be analysed by providing cross-language access to multilingual text databases (see http://www.hltcentral.org/projects/detail.php?acronym=LIQUID).

Data can also be organised in a way to convey a sense of the participants' identities (portraits), behaviours (based on interaction history) and spatial environment (based on movements and artefacts).

Collected data can be represented in the form of maps. There are mapping tools, such as the Coraler (www.coraler.com) or MindManager (www.mindmanager.com), which simplify the process of finding, retrieving and organising information (allowing visual organisation of web links for instance).

Finally, collected data can compared to an ontology for trails of LOs (see Chapter 8) in order to classify the different trails followed by users.

7.5 Examples of logs

Example of data that can be collected for video conferencing

- Unique contribution label
- Content of the contribution
- Number of the message in which the contribution appears
- Identifier of the message sender
- Messages expressing disagreement or agreement with the contribution

Example of indications that can be visualised in computer conferencing

- Time progression (chronological)
- Sender identity (by colour)
- Proposition and Queries
- Agreement and disagreement (+ and - symbols)

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About Chapter 8

The aim of Chapter 8 is to bring the results of the preceding chapters together. Chapter 8 describes a first attempt to set up a taxonomy that encompasses all types of trails that have been described in the preceding chapters and that at the same time distinguishes between these types of trails in a way that makes sense. The taxonomy includes several distinctions that have been made in previous chapters. One example is the distinction between trails that have been followed and trails that are to be followed. Another example is the classification of trails according to the majority type of learning object that make up the trail into learning object trails, result trails and discussion trails.

8   A Taxonomy of trails of Learning Objects

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8.1   Modelling the space of Learning Objects

We take as our domain of discourse the set of all LOs, both digital and non-digital, and the set of links between them (see Figure 16). We consider there to be a "link" from LO_a to LO_b when it is possible for a learner to interact with LO_b directly after interacting with LO_a (a **temporal** link), or when two LOs are connected by having related content (a **conceptual** link). The set of links is a set of binary relations.
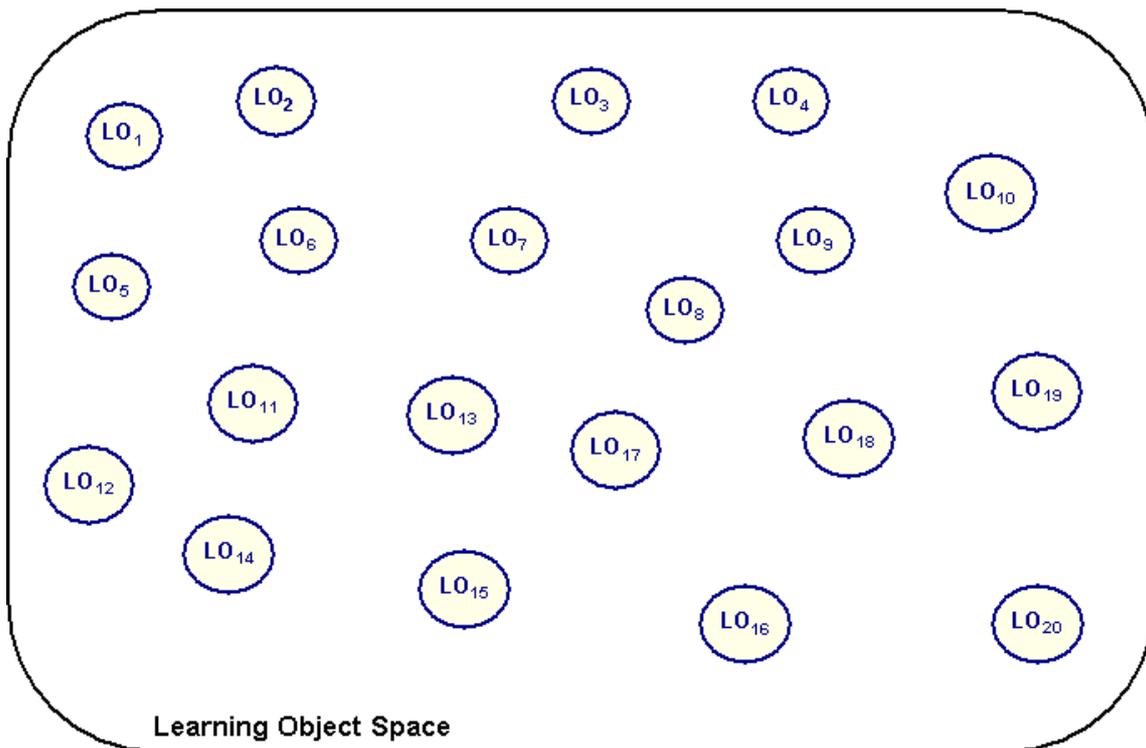
(a)
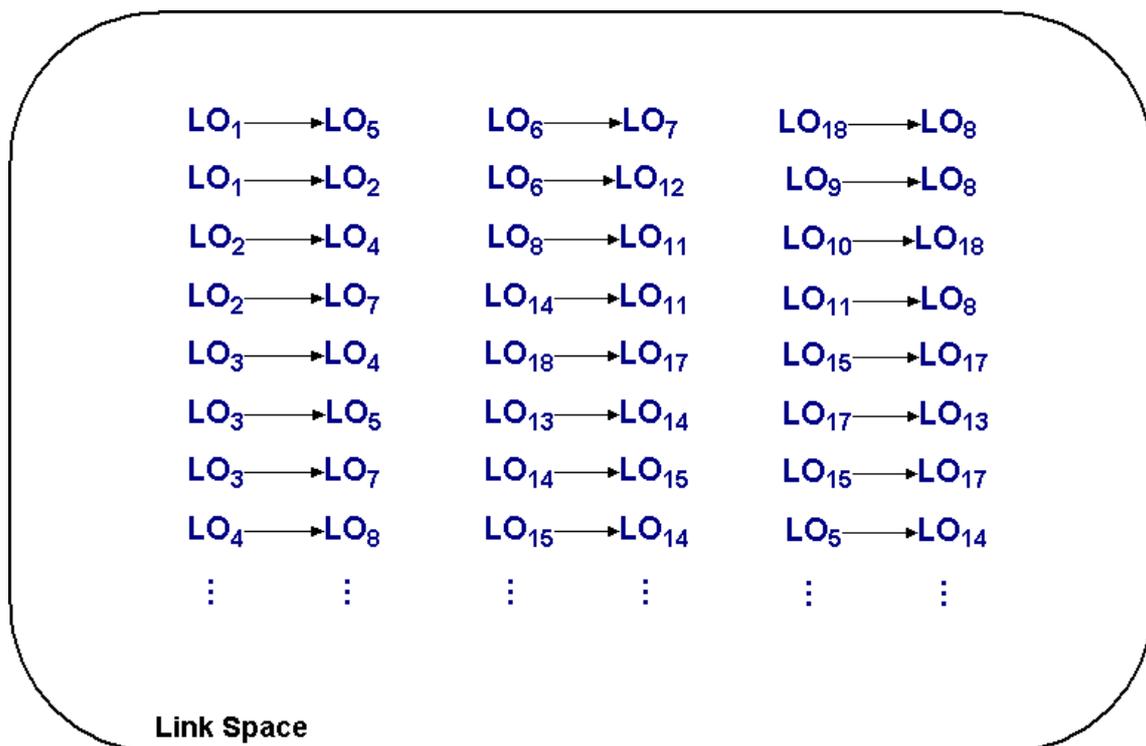
(b)

Figure 16. (a) The set of LOs and (b) the set of links between them

Considering the level of individual LOs and links is a very low-level view of the space. A high-level view is achieved by considering the graph formed by these two sets: The sets of LOs and links together form a network where the LOs are the nodes of the graph and the

links between LOs are the edges between nodes (see Figure 17). It is useful to consider the different networks formed by the different kinds of link separately – the temporal links form one network and the conceptual links another.
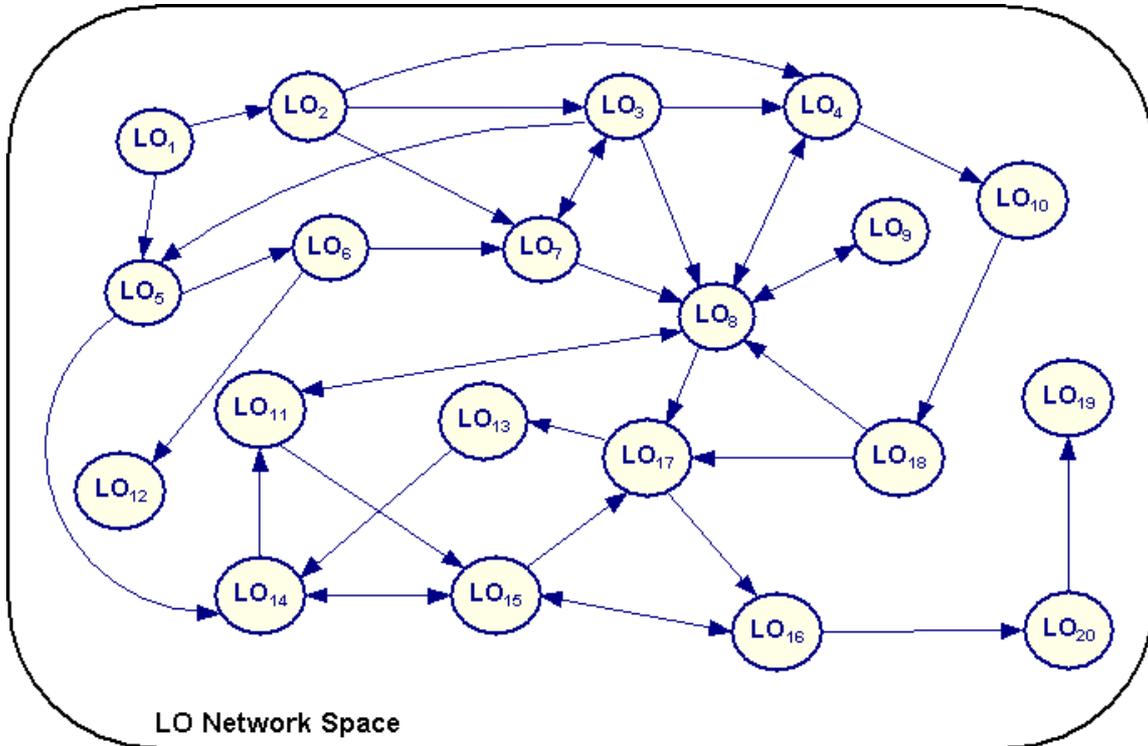
Figure 17. The network created by a set of LOs and the possible links between them

We are interested in two intermediate-level views of the LO spaces. The first level, above the link level, is the space of trails – linear sequences of LOs connected by links. A trail consists of one or more consecutive links (see Figure 18).

Figure 18. The space of LO trails

The next level, above the individual trail level but below the level of the entire LO network, is the space of learning environments and mind maps (also known as cognitive maps). These are formed from sub-sections of the network, consisting of one or more overlapping possible trails (see Figure 19).
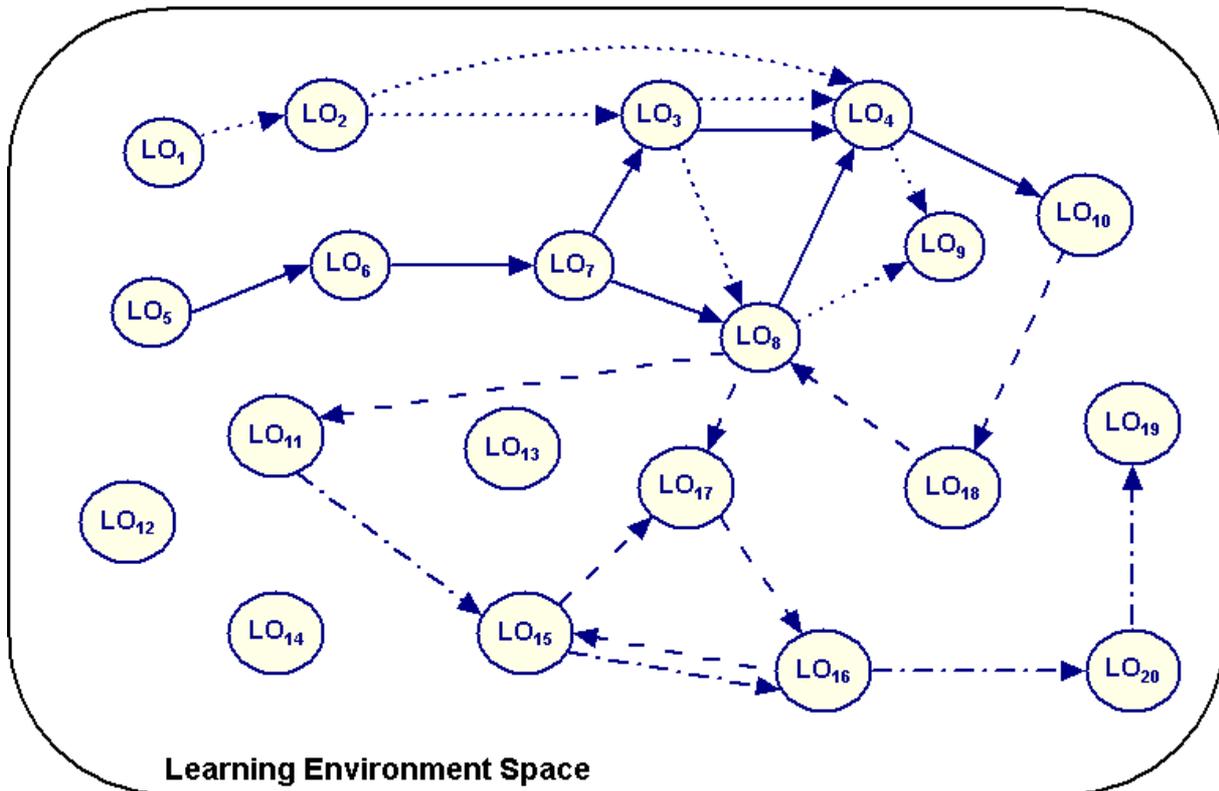
Figure 19. The space of learning environments – structures encapsulating possible trails

8.1.1 Types of LO

LOs can be classified along several dimensions, some of which we will use later on to aid our classification of trails:

- Whether they are digital or non-digital
- Whether or not they have been visited by the learner (or the group of learners) yet
- Their mode of creation – LOs could be:
  - Pre-authored by an instructor for educational purposes
  - Pre-existing objects not produced for educative purposes, for example a painting or artefact in a museum, a novel, a (non-educational) web page, a cliff face, a plant
  - Created by a learner or group in response to an LO or an assignment (a **result object**)
  - Created by a learner or group to initiate or respond to a discussion (a **discussion object**)
  - Created by an instructor in response to an LO created by a learner or group

The first two kinds of LO are available in the learning environment before a learner or group of learners begins to interact with it, but the others do not exist until a learner or group engages with the environment. Their existence can be predicted by an instructor who is designing a learning environment, but their content can not be known at design-time. For example, an instructor may know that a result object will exist in the environment at a later stage, as a response to an assignment say, but its contents will be unknown.

8.1.2 Types of link

Links can also be of various types. As mentioned in Section 8.1, the top-level distinction we make is between temporal links and conceptual links, and these sets of links give us two different networks of LOs. The identification of the sub-classes of temporal and conceptual links is less important in classifying trails – we can simply consider the links to be whatever needs to exist for trails to be possible. Temporal links allow LOs to be interacted with in sequence. Temporal links could be:

- Hyperlinks between web pages or in a hypertextual learning environment
- Physical adjacency, such as exhibits in a museum being next to one another or one chapter of a book following another

Conceptual links reflect connections between LOs based on their content. Conceptual links could be:

- When LO_a covers prerequisite knowledge for being able to interact with LO_b
- When one LO contains similar content to another LO, such as

    -LOs on the same topic

    -LOs teaching the same competency

    -LOs with the same learning objective

    -LOs containing examples demonstrating the same principle

8.2 Trails in the temporal link network

8.2.1 Categorising trails

The trails we consider are sequences of LOs that have been followed by a learner or group of learners to complete some learning task, and so are equivalent to the "Effected Trails" discussed in earlier chapters. The possible trails are defined by the space of learning environments, and different trails can be followed through the same learning environment. For example, the trails shown with solid (_____) and dotted (.....) lines in Figure 18 are both enactments of the learning environment shown with a solid (_____) line in Figure 19,

_____

and all the other trails shown in Figure 18 are enactments of one of the other learning environments of Figure 19. Learning environments roughly correspond to the "Planned Trails" of earlier sections.

Trails are initially categorised according to the type of LO forming the majority of the trail. Trails comprising mainly pre-existing LOs we call **LO trails** and those that are mostly discussion objects **discussion trails**. In the case of trails dominated by result objects the proportion of result objects is unlikely to be over 50%, as learners must first visit a LO before generating a reaction to it. For this reason we call this type of trail **visit and result trails**. If it is not clear which type of LO dominates the trail then the trail should be considered as a sequence of smaller, classifiable trails – for example, one long unclassifiable trail might break down to be considered as a LO trail followed by a discussion trail followed by another LO trail. These are useful pedagogical distinctions since different pedagogical designs tend to result in trails where one type of LO is dominant. For example, discussion trails will occur mostly in collaborative learning and LO trails in individualised learning.

A further classification of effected trails can be performed by considering whether the learner decided on the sequence of LOs independently, or whether a planned trail was explicitly followed. The former we call **emergent trails** and the latter **authored trails**.

Trails do not include decision points. They can, however, include as component LOs the results of decisions (such as learners' answers to a test) and other LOs created during the learning process (such as discussion messages). Trails can be 'recordings' of the enactment of learning environments, to aid with reflection and remembering.

8.2.2 Categorising learning environments

A learning environment is a set of one or more overlapping trails that could potentially be followed by a learner. Each learning environment is a sub-section of the network formed by considering all temporal links between LOs. The most basic learning environment is a single trail with no branch points, such as the learning environment shown dash-dotted (-.-.-.-) in Figure 19. We call such learning environments **simple learning environments**. Where overlaps do occur this results in a graph structure containing **decision points**, where the actions of the learner (such as their performance in an assessment) may determine different trails through the LO space.

The dotted (.....), dashed (-----) and solid(_____) learning environments in Figure 19 show environments with various different branching structures. We call such environments **compound learning environments**.

A further category of learning environment is formed when learners can freely choose between LOs – this is equivalent to there being two-way links between all LOs in the environment. We call such environments **open learning environments**. Within such environments the only trails that can be identified are emergent trails.

We classify learning environments (both simple and compound) separately from trails as *decision points are features of an environment, not of the trails followed by a learner*. For example, when a learner chooses which hyperlink to follow next, or which museum corridor to walk down, the links and corridors are features of the environment, not of the learning trail.

Learning environments can only contain LOs that exist at the time of planning, although they could include place-holders for LOs that will be generated by the learner when following one of the trails encapsulated by the learning environment.

8.2.3 Examples of different types of trail

- **LO Trails**
  - Navigation through any environment (physical or virtual) containing LOs
  - "Data selection" trails, where learners choose which data items to consider
  - Simulation LOs are a special case of LO trail, where parameters are manipulated as a method of hypothesis testing
- **Visit and Result Trails**
  - Mobile learning scenarios, where LOs are reactions to visited non-digital LOs
- **Discussion Trails**
  - Can occur in all learning scenarios where there is interaction between learners

8.2.4 Examples of different types of learning environment

- **Simple Learning Environments**
  - Trails consisting of some fixed introductory material on a topic, followed by some exercises and an assessment – such as provided by some of the more basic e-learning systems
- **Compound Learning Environments**

- Adaptive introduction-exercise-assessment type environments – such as might be provided by an intelligent tutoring system

- **Open Learning Environments**
  - LO repositories
  - The Web at large

8.3 Trails in the conceptual link network

Conceptual links are different from temporal links in that conceptual links form mind maps rather than LO networks. The conceptual linking of LOs into a mind map is a different kind of structuring of the LO space than that done in creating learning environments. Mind maps primarily organise **knowledge**, not LOs, so although the Coraler mapping tool allows maps of LOs to be created (see Section 3.2), these are actually a reflection of the learner's **cognitive trails**, and not LO trails *per se*. It might be interesting to compare learning environments with mind maps generated for the same LO space – a reasonable hypothesis might be that we would find that "good" learning environments (i.e. those most useful to learners) correlate closely to the mind maps created by domain experts.

8.3.1 Conceptual and Cognitive Trails

Another category of trail altogether (although it may not be a LO trail as such) is that of **reconstructed** or **refined trails**. These are trails organised by the learner in terms of their understanding of the concepts involved, rather than the actual sequence of LOs originally followed (their original effected trail). These trails are neither effected nor planned, but are instead reflections on the learner's current understanding of a topic.

The original temporal sequence (the effected tail) can be seen as the starting point for the development of these refined trails – in this sense they could be called **ampliative trails**. The work on cognitive trails in TRAILS deliverable 1.1 (Kaleidoscope deloverable 22.1.1) may inform the future extension of our taxonomy with categories of cognitive trail.

8.4 Trails taxonomy

A summary of the classification systems for trails and learning environments can be found in Figure 20.

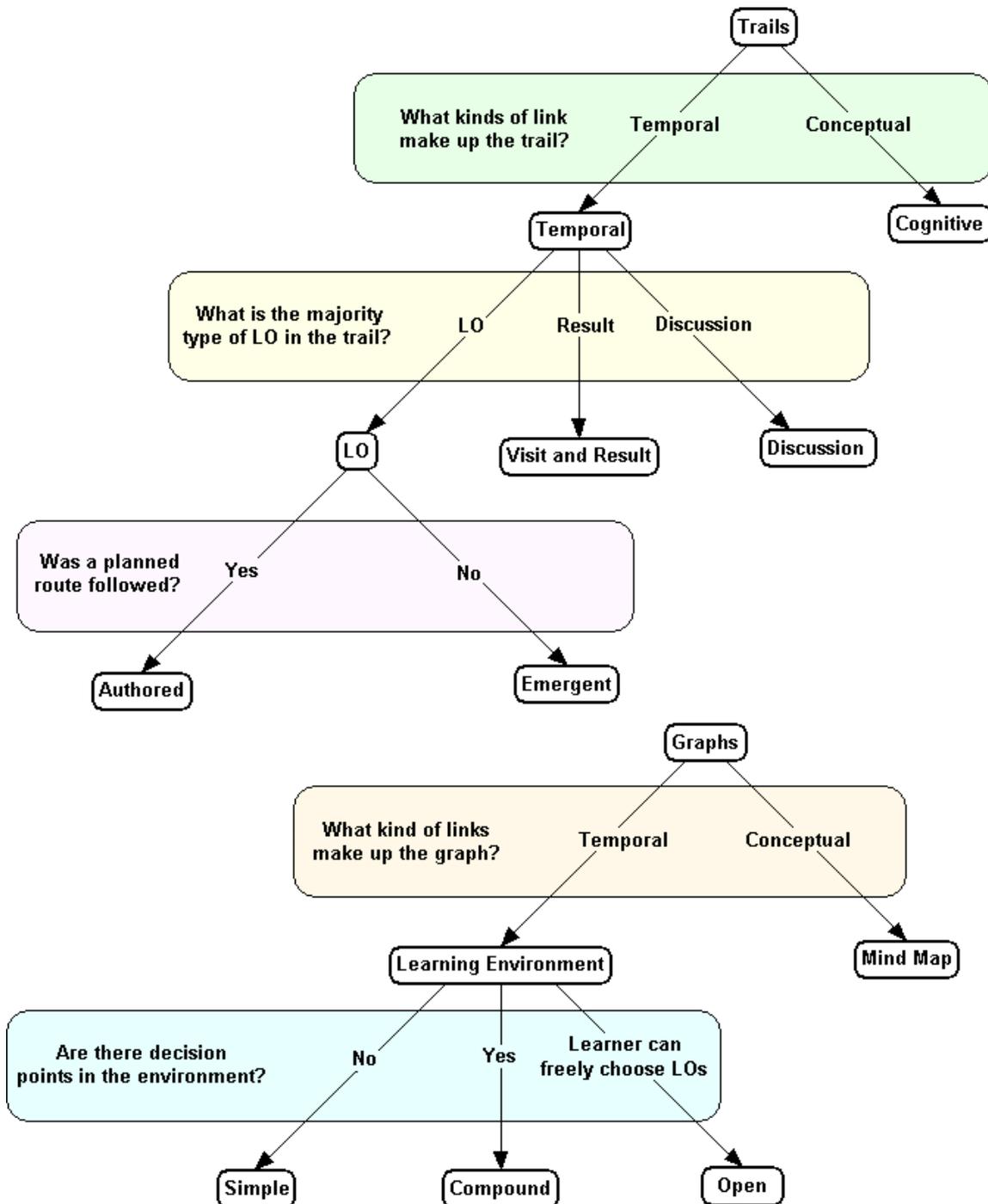*Figure 20. A classification of trails and learning environments*

8.5 Notes on Standardisation

This taxonomy will be expanded and refined in TRAILS Workpackage 4 (see Kaleidoscope Deliverables 22.4.1 and 22.4.2, forthcoming). Once the final taxonomy is decided upon it could be represented using XML, or something more sophisticated such as RDF (Resource Description Framework) or OWL (Web Ontology Language).

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Appendix 1: translation XML with DTD IMS-LD

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- <!-- Ce document de Fee carabine est crée avec le Schema XSL de IMS-LD - Attention ! au niveau A - ce document est bien-formé pas le schema IMSLD ainsi que validé par XML SPY Au niveau B - ce document est bien-formé par XML SPY -->

- <!-- Schema IMS-LD -->

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- <!-- Rôles des acteurs Enseignants -->
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- <imsld:properties>
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- `<imsld:activity-description>`

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  `identifierref="`**Ressources-PrendrePosition**`">`

  `<imsld:title>`**Prendre Position**`</imsld:title>`

  `</imsld:item>`

  `</imsld:activity-description>`

- `<!--` A la fin de l'activité Prendre position Propriétés

  = Vrai `-->`

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  = Vrai -->
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- `<imsld:learning-activity identifier="`**AA9_NegocierSynthèse**`">`
- `<imsld:activity-description>`
  `<imsld:title>`**Description de l'activité**`</imsld:title>`
- `<imsld:item identifier="`**I_NegocierSynthese**`"`
  `identifierref="`**Ressources-NegocierSynthese**`">`
  `<imsld:title>`**Negocier Synthese**`</imsld:title>`
  `</imsld:item>`
  `</imsld:activity-description>`
  `<imsld:environment-ref ref="`**La_Synthese**`" />`
  `<imsld:environment-ref ref="`**Editeur_de_texte**`" />`
  `<imsld:time-limit>`**10 mn**`</imsld:time-limit>`
  `</imsld:learning-activity>`
- `<!--` AA Presenter Synthese `-->`
- `<imsld:learning-activity identifier="`**AA10_PresenterSynthèse**`">`
- `<imsld:activity-description>`
  `<imsld:title>`**Description de l'activité**`</imsld:title>`
- `<imsld:item identifier="`**I_PresenterSynthese**`"`
  `identifierref="`**Ressources-PresenterSynthese**`">`
  `<imsld:title>`**Presenter Synthese**`</imsld:title>`
  `</imsld:item>`
  `</imsld:activity-description>`
  `<imsld:environment-ref ref="`**La_Synthese**`" />`
  `<imsld:environment-ref ref="`**Editeur_de_texte**`" />`
  `<imsld:time-limit>`**10 mn**`</imsld:time-limit>`
  `</imsld:learning-activity>`
- `<!--` Description des activités de Soutien `-->`
- `<!--` AS Presenter Etape `-->`
- `<imsld:support-activity identifier="`**AS1_presenterEtape**`">`
- `<imsld:activity-description>`
  `<imsld:title>`**Description de l'activité**`</imsld:title>`
- `<imsld:item identifier="`**I_PresenterEtape**`"`
  `identifierref="`**Ressources-PresenterEtape**`">`
  `<imsld:title>`**Presenter Etape**`</imsld:title>`
  `</imsld:item>`
  `</imsld:activity-description>`

```
<imsld:environment-ref ref="Le_Sujet" />
</imsld:support-activity>
<!-- AS Nommer Rapporteur -->
<imsld:support-activity identifier="AS4_NommerRapporteur">
<imsld:activity-description>
<imsld:title>Description de l'activité</imsld:title>
<imsld:item identifier="I_NommerRapporteur"
identifierref="Ressources-NommerRapporteur">
<imsld:title>Nommer Rapporteur</imsld:title>
</imsld:item>
</imsld:activity-description>
<imsld:environment-ref ref="La_Synthese" />
<!-- A la fin de l'activité nommer rapporteur
Propriétés = Vrai -->
<imsld:on-completion>
<imsld:change-property-value>
<imsld:property-ref
ref="Un_eleve_est_identifié_comme_rapporteur" />
<imsld:property-value>true</imsld:property-value>
</imsld:change-property-value>
</imsld:on-completion>
</imsld:support-activity>
<!-- AS Reguler Debat -->
<imsld:support-activity identifier="AS5_RegulerDebat">
<imsld:activity-description>
<imsld:title>Description de l'activité</imsld:title>
<imsld:item identifier="I_RegulerDebat" identifierref="Ressources-
RegulerDebat">
<imsld:title>Reguler Debat</imsld:title>
</imsld:item>
</imsld:activity-description>
<imsld:environment-ref ref="Le_Forum" />
</imsld:support-activity>
<!-- Description des activités Structurées -->
<!-- AG Preparer Debat -->
```

```xml
– <imsld:activity-structure identifier="AG1-PreparerDebat" number-to-
  select="2" structure-type="sequence">
  <imsld:title />
  <imsld:learning-activity-ref ref="AA2_LireConsignes" />
  <imsld:learning-activity-ref ref="AA2_LireChapitre" />
  <imsld:environment-ref ref="Le_Sujet" />
  </imsld:activity-structure>
- <!-- AG debattre Argument/Position -->
– <imsld:activity-structure identifier="AG2-DebattreArgumentPosition"
  number-to-select="2" structure-type="sequence">
  <imsld:title />
  <imsld:learning-activity-ref ref="AA7_DonnerArgument" />
  <imsld:learning-activity-ref ref="AA6_PrendrePosition" />
  <imsld:environment-ref ref="Le_Forum" />
  </imsld:activity-structure>
- <!-- AG Debattre Position/Argument -->
– <imsld:activity-structure identifier="AG3-DebattrePositionArgument"
  number-to-select="2" structure-type="sequence">
  <imsld:title />
  <imsld:learning-activity-ref ref="AA6_PrendrePosition" />
  <imsld:learning-activity-ref ref="AA7_DonnerArgument" />
  <imsld:environment-ref ref="Le_Forum" />
  </imsld:activity-structure>
- <!-- AG Débattre -->
– <imsld:activity-structure identifier="AG4-Debattre" number-to-select="2"
  structure-type="sequence">
  <imsld:title />
  <imsld:learning-activity-ref ref="AG2-DebattreArgumentPosition" />
  <imsld:learning-activity-ref ref="AG3-DebattrePositionArgument" />
  </imsld:activity-structure>
  </imsld:activities>
- <!-- Environnements -->
– <imsld:environments>
- <!-- Environnement Sujet -->
– <imsld:environment identifier="Le_Sujet">
  <imsld:title>Sujet du cours</imsld:title>
```

```
    </imsld:environment>
-   <!-- Environnement Chapitre -->
–   <imsld:environment identifier="Le_Chapitre_du_livre">
    <imsld:title>Chapitre du livre</imsld:title>
    </imsld:environment>
-   <!-- Environnement Synthese -->
–   <imsld:environment identifier="La_Synthese">
    <imsld:title>Synthese du livre</imsld:title>
    </imsld:environment>
-   <!--
    Environnement Forum
    -->
–   <imsld:environment identifier="Le_Forum">
    <imsld:title>Forum du livre</imsld:title>
    </imsld:environment>
-   <!--
    Environnement Forum
    -->
–   <imsld:environment identifier="Editeur_de_texte">
    <imsld:title>Editeur de texte</imsld:title>
    </imsld:environment>
    </imsld:environments>
    </imsld:components>
-   <!--
    Play
    -->
–   <imsld:method>
–   <imsld:play>
-   <!--
Acte 1: La Presentation de l'étape
    -->
–   <imsld:act>
    <imsld:title>ACTE 1</imsld:title>
–   <imsld:role-part>
    <imsld:role-ref ref="Directeur" />
    <imsld:learning-activity-ref ref="AS1_presenterEtape" />
```

```
     </imsld:role-part>
     </imsld:act>
-  <!-- Acte 2: La Preparation du débat -->
–  <imsld:act>
   <imsld:title>ACTE 2</imsld:title>
–  <imsld:role-part>
   <imsld:role-ref ref="Membre_du_groupe" />
   <imsld:learning-activity-ref ref="AG1-PreparerDebat" />
   </imsld:role-part>
   </imsld:act>
-  <!-- Acte 3: Nommer le rapporteur -->
–  <imsld:act>
   <imsld:title>ACTE 3</imsld:title>
–  <imsld:role-part>
   <imsld:role-ref ref="Groupe" />
   <imsld:learning-activity-ref ref="AS4_NommerRapporteur" />
   </imsld:role-part>
   </imsld:act>
-  <!-- Acte 4: Le Debat -->
–  <imsld:act>
   <imsld:title>ACTE 4</imsld:title>
–  <imsld:role-part>
   <imsld:role-ref ref="Directeur" />
   <imsld:learning-activity-ref ref="AS5_RegulerDebat" />
   </imsld:role-part>
–  <imsld:role-part>
   <imsld:role-ref ref="Membre_du_groupe" />
   <imsld:learning-activity-ref ref="AG4-Debattre" />
   </imsld:role-part>
-  <imsld:role-part>
   <imsld:role-ref ref="Rapporteur" />
   <imsld:learning-activity-ref ref="AA8_NoterInterventions" />
   </imsld:role-part>
   </imsld:act>
-  <!-- Acte 5: La négociation de la synthese -->
–  <imsld:act>
```

```
<imsld:title>ACTE 5</imsld:title>
- <imsld:role-part>
  <imsld:role-ref ref="Rapporteur" />
  <imsld:learning-activity-ref ref="AA9_NegocierSynthèse" />
  </imsld:role-part>
  </imsld:act>
- <!-- Acte 6: La presentation de la synthese -->
- <imsld:act>
  <imsld:title>ACTE 6</imsld:title>
- <imsld:role-part>
  <imsld:role-ref ref="Rapporteur" />
  <imsld:learning-activity-ref ref="AA10_PresenterSynthèse" />
  </imsld:role-part>
  </imsld:act>
- <!-- Fin de l'activité -->
  </imsld:play>
  </imsld:method>
  </imsld:learning-design>
  </imscp:organizations>
- <!-- Les Ressources -->
- <imscp:resources>
  <imscp:resource identifier="Ressources-Prerequis" type="" />
  <imscp:resource identifier="Ressources-ObjectifActivité" type="" />
  <imscp:resource identifier="Ressources-LireConsignes" type="" />
  <imscp:resource identifier="Ressources-LireChapitre" type="" />
  <imscp:resource identifier="Ressources-PrendrePosition" type="" />
  <imscp:resource identifier="Ressources-DonnerArgument" type="" />
  <imscp:resource identifier="Ressources-NoterInterventions" type="" />
  <imscp:resource identifier="Ressources-NegocierSynthese" type="" />
  <imscp:resource identifier="Ressources-PresenterSynthese" type="" />
  <imscp:resource identifier="Ressources-PresenterEtape" type="" />
  <imscp:resource identifier="Ressources-NommerRapporteur" type="" />
  <imscp:resource identifier="Ressources-RegulerDebat" type="" />
  </imscp:resources>
    </imscp:manifest>
```