

Lifelong Learning Organisers: Requirements for tools for supporting episodic and semantic learning

Giasemi Vavoula

Department of Museum Studies, University of Leicester, United Kingdom // Tel: +44 1162523963 // Fax: +44 1162523960 // gv18@le.ac.uk

Mike Sharples

School of Education, University of Nottingham, United Kingdom // Tel: +44 115 9513716 // Fax: +44 115 8467931 // mike.sharples@nottingham.ac.uk

ABSTRACT

We propose Lifelong Learning Organisers (LLOs) as tools to support the capturing, organisation and retrieval of personal learning experiences, resources and notes, over a range of learning topics, at different times and places. The paper discusses general requirements for the design of LLOs based on findings from a diary-based study of everyday learning practice; and also based on the design and evaluation of KLeOS, a prototype LLO that supports learning projects, episodes and activities through the linking of learning content with semantic and episodic context. We suggest that LLOs should assist in capturing both the episodic and the semantic aspects of learning events, and should incorporate retrieval mechanisms that utilise both types of memory (i.e. episodic and semantic) to assist tracing back knowledge and resources. Issues for future research on LLOs are also discussed.

Keywords

Lifelong Learning Organisers, activity-based interface, continuous archival and retrieval of personal learning, episodic and semantic memory, concept maps, timelines, personal learning environment

Introduction

Traditional conceptions of learning as a classroom-based activity are expanding to recognize the value of informal, self-directed learning. Learning surveys carried out since the 1970s (Livingstone 2000; 2001; Tough 1971) consistently show that a large proportion of learning takes place outside educational institutions and pertains to the learner's personal interests and everyday life demands. Recently in the UK the Department for Innovation, Universities and Skills (DIUS) launched a consultation into the development of a government strategy for adult informal learning in the 21st Century, endorsing the value of informal learning for the well-being and prosperity of society and its citizens. One of the themes addressed in the consultation process is concerned with how we can improve the connectivity between different kinds of learning episodes (DIUS 2008). This paper is concerned with the design of tools to support adults in consolidating personal learning experiences across contexts through capturing, inter-relating, organising and retrieving learning events, associated learning resources, and the knowledge and skills learned *en route*. These we call Lifelong Learning Organisers (LLOs), defined as systems that assist learners in organising learning activities, episodes and projects, the knowledge they learn, and the resources they use, over a range of learning topics, at different times and places, in ways that integrate their learning experiences to create personal, meaningful records of their learning over a lifetime. LLOs are thus valuable cognitive as well as practical tools for the self-organised learner.

LLOs as cognitive tools are underpinned by constructivist conceptions of learning (Bruner 1960), which maintain that meaning is constructed by the learner through the association and integration of the new information with what they already know. Learning is dependent on the learner's interpretation of experience, which results in the assimilation and accommodation of new information within previous learnt knowledge structures. By providing the means to capture experience, the knowledge gained from it, and the associations between aspects of the experience and knowledge gains as well as between different experiences, LLOs can assist reflection and consolidation of experience and knowledge.

LLOs as practical tools build upon the everyday learning practices of archiving and reviewing learning materials. Archiving of personal notes, paper-based and electronic documents, emails and other types of material is common practice amongst learners of all levels and ages. Personal methods for archiving learning can vary from maintaining an elaborate archiving system with an underlying categorisation hierarchy accompanied by systematic, neat note-

taking, to ‘messy’ piles of documents on a desktop complemented by sticky notes. Studies of memory and learning suggest that recording and archiving activities (e.g. note taking) may assist a number of cognitive processes involved in learning, such as the encoding and storage of information (see for example Kobayashi 2006). For example, the value of revisiting experiences to evaluate and improve performance is an essential part of modern sports training: a coach will often review a video record of an athlete’s performance to reflect with the athlete on how to improve techniques and overcome weaknesses. LLOs support and extend the archival and retrieval of personal experiences to all areas of personal learning.

LLOs provide a means to capture the structure of learning and how it relates to the learnt knowledge. These make up the episodic and semantic parts of a learning event respectively. The terms episodic and semantic are used here in the same sense as in Tulving’s (1983) memory model: episodic memory is involved in the recording and subsequent retrieval of memories of personal happenings and doings, while semantic memory is the store of general facts and knowledge of the world that is independent of a person’s identity and past. At least one type of memory is consulted in knowledge retrieval.

This allows us to make a distinction between episodic and semantic learning context. Episodic context consists of the practical specifics of a learning experience (information about when, where, with whom, and how we practice learning). Semantic context consists of the scaffold that accommodates the gist of our learning experiences (the web of associations between terms and concepts that allows the newly learned to ‘slot into’ what we already knew). Recollections of episodic context are used in re-establishing the sequence of learning activity from a personal perspective, and recollections of semantic context are used to put the knowledge gained in one context to use in another context.

This distinction can be useful in analysing learning context as an instrument for organising learning experiences, resources and content, and utilising them to re-establish the structure and content of prior learning. Tools for utilising and supporting episodic context include diaries, planners, and personal organisers (episodic organisers). Tools for the development and organisation of external representations of semantic context include concept maps and note books (semantic organisers). LLOs provide a combination of both types of tool, allowing people to capture and retrieve their learning episodes and also their related, interconnected knowledge. They achieve this by utilising external representations of semantic and episodic context to enable the learner to easily capture episodic learning and to couple it to the scaffold of concepts and associations that constitutes semantic learning. The LLO presents these linked representations back to the learner upon request for reflection and reuse.

Applications of concepts for capturing and indexing everyday life events and thoughts range from Vannevar Bush’s MEMEX (Bush 1945) to the more recent MyLifeBits project at Microsoft (Gemmell *et al.* 2002), the Memories for Life UK Grand Challenge (Fitzgibbon & Reiter 2003), and the Learning for Life UK Grand Challenge (Taylor *et al.* 2006). Placed in this context, the paper seeks to inspire research and development work in LLOs through suggesting an initial list of general requirements for LLOs. The methods used to elicit the requirements are described. These included a ‘diary: diary-interview’ study of personal learning episodes; and the design and evaluation of a prototype LLO called KLeOS. A gradual presentation of the resulting requirements follows, starting with those emerging from the diary study and continuing with those that emerged from the evaluations of KLeOS. The paper concludes with a discussion of future research issues for the design of LLOs.

Methodology and methods

The work reported here followed the Socio-Cognitive Engineering (SCE) approach (Sharples *et al.* 2002). SCE is a coherent approach to describing and analysing the complex interactions between people and technology, so as to inform the design of socio-technical systems (technology in its social and organisational context), while paying attention to the transformations to practice brought about by the introduction of the new technology (Taylor *et al.* 2006). SCE has two stages: an analysis stage and a design stage. Analysis involves an investigation into how activities are performed in their normal contexts on one hand, and a theory-based study of the underlying cognitive and social processes on the other. These lead to the definition of a task model that provides a structured account of how the activities are currently performed, the people involved, their contexts, the tools and technologies they employ, the structure of the tasks and an account of their cognitive processes, management of knowledge, and social interactions. In the design stage, the task model acts as the basis for the development of a design concept, which is

used to generate a space of possible system designs. This process leads to the specification of the functional and non-functional aspects of the system, and concludes with implementation. SCE affords further iterations, whereby the transformations to patterns of work and social interaction brought about by the new system become contexts for further analysis and design. We report here the outcomes of the first iteration of SCE to the design of LLOs.

The analysis stage consisted of a diary-based study of the everyday learning practice of 12 individuals. The study has borrowed techniques from qualitative research to produce a data-grounded and theory-informed descriptive Framework of Lifelong Learning (Vavoula 2004), which identifies core concepts and patterns in the practice of everyday learning, and which corresponds to the task model. The framework was analysed further to infer general requirements for lifelong learning support systems.

The design stage involved the specification of a design framework based on the requirements produced in the first part; and the specification (by design and implementation) of a solution to match the design framework. The outcome was the prototype system KLeOS (Knowledge and Learning Organisation System), a system that enables the user to perform and organise learning activities, episodes and projects, and to associate them with the notes they make of the knowledge and skills learned in the process, over a lifetime. The analysis and evaluation of the prototype (through a controlled learning task with a group of 14 users) have led to the refinement and extension of the original requirements to specify requirements for a particular class of lifelong learning support tool, which we have named Lifelong Learning Organisers.

Studying the learning practice: general requirements for LLOs

The study of everyday learning practice used the “diary: diary-interview” method (Zimmerman & Wieder 1977) for data collection and an adaptation of Grounded Theory (Glaser & Strauss 1967) for data analysis. Twelve adults participated, of ages between early twenties and late forties. Six of them were postgraduate students, one was an undergraduate student, one was a lecturer, two were university secretarial/technical staff, one was a school careers advisor, and one was a researcher. The participants were asked to keep a diary of their everyday learning events over a period of four days, making notes of their physical and social context, the activities they performed, the resources they used, and the problems they were faced with. This was followed by semi-structured interviews lasting on average one and a half hours that focused on the participants’ logged data and on their learning practices in general.

The received entries varied in nature from classroom-based learning, to lab-based collaboration, and everyday life problem-solving (e.g. learning how to send flowers through Interflora). Detailed results can be found in Vavoula (2004); an overview of the collected data and methods can be accessed online at <http://www.eee.bham.ac.uk/vavoula/PhD/FieldStudies.htm>. The data was analysed following the principles of Grounded Theory, using the constant comparative method for qualitative analysis (Glaser & Strauss 1967). The outcome of the analysis has been a descriptive Framework of Lifelong Learning that identifies core concepts and categories in the process of everyday learning. The development of the framework involved a 4-step analysis of the diary and interview data. In step 1 the diary and interview data were segmented into extracts. For the diary, the segmentation was performed based on the distinct learning experiences described by the participants. For the interview, the segmentation was based on the identification of points in the dialogue where a shift of focus occurred. In step 2, extracts were summarised and tagged with topic indicators. In step 3, the topic narratives were recapitulated and associated with emerging issues. In step 4, concepts and categories related to the issues were identified. Table 1 illustrates the analysis process and the progression from raw data to concepts and categories of the framework. It depicts only a part of the framework related to note-taking.

Table 1: Example of the process of analysis, from diary-interview data to categories of Framework of Lifelong Learning

Diary & Interview Extracts 3A, 3U, 3T	Diary: <i>“-Do you use a notebook? For what kind of notes? - Yes. Notebook 1: for personal reminders, e.g. train times, shopping lists. Notebook 2: academic work, e.g. notes from meetings with supervisors.”</i>
	Interview: <i>“...I would write [in my diary] something that I've learned, that I need the 5:15 train, it's not as learning orientated as my academic notebook which I will miss not having if I, you know, was at a supervision... But [the academic notebook is] not something that I would carry around with me for my great thoughts.”</i>
	Interview: <i>“The little notebook is in my bag most of the time. And I will use that for recording general</i>

	<p>information like train times or for lists of what I need to go shopping for, who I'm going to send Christmas cards to, the general no-work-related. The academic notebook is a big A4 book that usually sits on my desk in the office, it very rarely comes home with me ... in which I keep track of progress purely related to work. And it's a combination of things to do, things to read and what I'm interested in doing myself, my thoughts on [...] [There is] very little overlap. There might be an overlap when somebody gives me a phone number or something and I don't have my [diary] [...] it has happened that I give them my notebook for them to write it in and then I'll transfer it to my diary, so it's duplicating like that. The notebook doesn't tend to have dates of things to do in it. It has goals to be achieved. [...] If I looked for a specific train time then I will put it in my diary "getting 5:15 to London". And it will go straight into the diary. If I have train times for getting from University into town as general train times, which are in my other notebook. And I keep on referring to that [...] So it would be more general."</p>
Topic 3S	<ul style="list-style-type: none"> • One notebook for academic work. Notes down things about supervision meetings, like what supervisors think should be doing next and their comments. Keeps in it track of work-related progress – a combination of things to do, things to read, thoughts, personal interests. • Academic work notebook is big A4 book that stays on desk. Always takes it with her at meetings, and rarely at home. • Also has 'little notebook' for general things. Carries it in her bag most of the time. Records in there general information (shopping lists, Christmas cards lists, general non-work-related information).
Concepts & Categories	<p>Category: Learning Activities Sub-category: Note-taking Concepts (italics indicate those related to Issue 3C):</p> <ul style="list-style-type: none"> Timing (during/after activity) Content, structure and format of notes Types of content (thoughts, general information, references, to-do items, reminders) Structure of content (by recording device, by physical proximity of related items, by temporal sequence) Adequacy of notes Ownership Notes recording devices Utility of notes

In brief, the Framework of Lifelong Learning describes learning practices in terms of: the learner; the hierarchical organisation of learning into projects, episodes and activities; the learning objects that are used, manipulated, organised, archived and retrieved during learning; the outcomes of the learning process; the breakdowns that occur because of, or during the learning process, or which are the cause of learning; and the social, physical and personal contexts of learning.

The Framework of Lifelong Learning was further analysed to draw out general requirements for lifelong learning support systems. This process involved re-examining the framework as one that describes a practice of learning in which an imagined tool to support the learning process is always available. At the time of producing the requirements this learning tool was thought of as a generic "black box": any explicit or implicit references in the framework to any form of support that the learner actually receives, could receive, or wishes to receive during learning were attributed to that tool without assuming or specifying anything about the tool's form or structure. The process resulted in an indicative set of general requirements under six main categories. A title, justification (founded on the explicit/implicit references to support in the framework) and specifics (detailing the requirement) of each category are given below:

1. Title: Assist the organisation of learning into projects, episodes and activities.
Justification: The learning practice is organised into three levels of granularity. At the finest level, the learner performs learning activities (such as reading, discussing, reflecting, and making notes). These are grouped together in a middle level by thematic, temporal and/or spatial proximity of context to form learning episodes (i.e. time-delimited learning events). At the coarsest level, learning projects are formed as collections of (past and future) episodes that exhibit some contingency in terms of purposes and/or outcomes. This organisation may

be intentionally designed into the learning practice (for example when the learner structures their learning by setting goals and objectives, and planning a route through a physical or conceptual learning space). Or it may emerge from the learning practice (for example when the learner dwells on everyday tasks and activities that have learning side effects, which are reflectively organised into learning projects).

Specifics: Assist learners to (a) plan and manage learning projects, (b) organise and complete learning episodes for their projects, and (c) perform common learning activities during their learning episodes.

2. **Title:** Adapt functionality to suit learner characteristics.

Justification: A learner has certain physical characteristics (and thereby physical abilities or disabilities), assumes a number of social roles (a colleague, a friend, a parent, etc.) and has a number of characteristics that relate to how (s)he practises learning (cognitive styles, learning tactics, preferences, etc.). Some of these may change with time; and they all influence the learner's planning of projects, experience of episodes, and performance of activities.

Specifics: The system should gather information on (long-term and short-term) learner characteristics and adapt its functionality appropriately.

3. **Title:** Support the learner's communications and collaboration with other people.

Justification: While learning can be a solitary experience, other people are often involved in learning episodes (53% of the episodes reported involved other people: co-learners, teachers, colleagues, or strangers). Communications vary in terms of synchronicity, media used, structure and degree of formality, and roles adopted by the participants. Collaboration involves the (co-)construction and sharing of objects, resources and conceptualisations. Common problems with communications and interactions with other people include identification of the right person to involve, availability and willingness to participate, and cultural discrepancies.

Specifics: The system should support the learner at all phases of communicating and learning with other people, including identifying and selecting appropriate people to learn with/from (e.g. by monitoring previous learner evaluation of their helpfulness, recommendations, etc.), establishing a communication channel, and exchanging effective representations of understandings irrespective of background differences.

4. **Title:** Support the learner in problem solving.

Justification: Only a third of the reported episodes happened without any problems. For the rest the learners reported problems relating to time management or to the learning objects used, and also emotional, physical and learner-specific problems. Problems can interrupt or initiate the learning process, as sometimes learning is the means to solve a problem which may have originated in an area of life that is not associated with a learning project (e.g. figuring out how to fix a broken piece of home machinery).

Specifics: Support the user in dealing with problems whether these problems come about in the course of learning, or are the object of learning.

5. **Title:** Assist in the use of learning objects.

Justification: Learners interact with objects that can support learning, such as information resources and memory aids, as well as with conceptual 'objects' like thoughts, ideas and understandings. Objects are discovered, assessed for suitability, accessed, manipulated, evaluated, archived, stored (or disposed of), and re-used or referenced.

Specifics: Assist in the use of physical, tangible objects, such as a piece of machinery; as well as of non-physical, intangible objects, such as reflections, by enabling the construction of a material representation of these objects. Assist the learner in all phases of an object's lifecycle: discover and identify what is suitable for the task at hand, get access to it, use it, evaluate it, and store, organise or dispose of it depending on its assessed utility. Assist the user to re-discover previously used objects.

6. **Title:** Adapt functionality to suit the context of learning.

Justification: Learning context consists of the time and timing of learning; the physical and social settings; the resources, information and learning topic; the learner status and objectives; and its connections with other instances of learning. The instantiation of these elements in each learning episode influence the learning practice. For example, the availability (or lack of) certain resources and people, the structure and hierarchy of the social setting, the learner's objectives and previous knowledge, all influence how learning will take place in terms of selected activities, the way they are carried out, and their outcomes. Knowing the context of learning leads to better support, tailored to the learner's needs at any time.

Specifics: Monitor the elements of the context of learning and how it evolves in the process of learning, so as to be able to provide context-specific support.

The first of the six top-level requirements (assist the organisation of learning into projects, episodes and activities) formed the backbone of the design framework for the second stage of SCE, leading to the conceptualisation of the intended system as a Lifelong Learning Organiser. Based on the design framework, the general requirements were re-interpreted into elements of a design solution. Table 2 presents the progression from requirements, to design framework, to elements of the design solution.

It should be noted here that the process of re-interpreting requirements into a design solution is not univocal. General requirements specified the type of learning tool (i.e. LLO) but not the specific form it would assume: the interface, the interaction components, how data is presented to and requested from the user. The conception of the details of the form in the shape of design solution elements brings up another level of functionality, relating to the specifics of the form rather than the purposes it serves. It was not possible to specify this functionality through an *a priori* study of the learning practice and was thus stipulated at design time. Thus, in addition to the requirements that transpired through the analysis of the diary study, additional requirements emerged through the new possibilities identified in the conception of the design solution.

The second stage of SCE proceeded with the design of a prototype LLO called KLeOS (Knowledge and Learning Organisation System). Evaluations of the prototype reinforced the requirements captured at design time. Moreover, reflecting on the users' perceptions of the system during the evaluation, has led to the formulation of additional requirements for LLOs. The design of KLeOS, its evaluation and the additional requirements that emerged from these exercises, will be present in the following section.

Additional requirements emerging from the evaluation of a prototype LLO

KLeOS: A Knowledge and Learning Organisation System

KLeOS supports the organisation of learning experiences, resources and knowledge over a lifetime. It allows the monitoring of learning projects, the organisation of learning episodes, and the performance of learning activities; while at the same time it enables the capturing of the learned knowledge by facilitating note taking during and after the learning episode via a basic concept mapping tool. A bridge is formed between the captured episode data and the learner's notes by tagging the notes with information about the related activities, episode and project; and by linking the activities with the related notes. The captured episode data, the notes, and the links between them are utilised in the retrieval of past knowledge and learning.

Table 2: From requirements to design framework to design solution elements

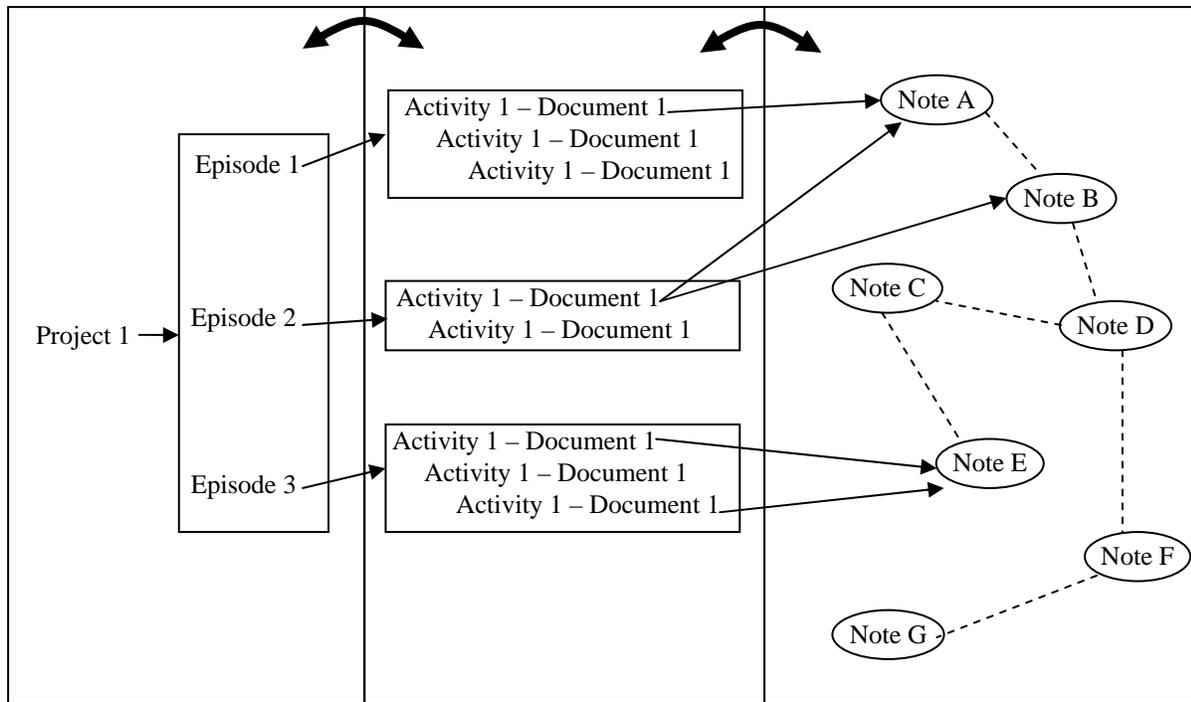
Requirement	Design framework	Design solution elements
1. Assist the carrying out of learning projects (including planning, assessing and evaluating, as well as related serendipitous learning); support the user's learning episodes; assist the performance of learning activities	Organise and structure the performance of lifelong learning	<ul style="list-style-type: none"> • Provide a timeline representation of projects indicating start, end, priority, topic, objectives, relevant episodes • Provide integrated environment for performing episode, optionally matching episode to project, monitoring episode location, people, objects and other context features, relevant activities • Within the episode environment, provide tools for the manipulation of learning objects and the performance of learning activities
2: Adapt functionality to suit learner characteristics	Accommodate learner preferences (e.g. for tools or methods) and objectives	<ul style="list-style-type: none"> • Allow learner to use favourite tools and styles for carrying out activities (e.g. favourite word processor, note taking style, etc.) • Aid learner to summarise and review progress
3: Support the learner's communication and collaboration with other people	Consider communications as a form of learning object	<ul style="list-style-type: none"> • Support communication as a learning activity
4: Support the learner in	Offer the means to review	<ul style="list-style-type: none"> • Support the learner to retrieve and review

problem solving	past practice in problem solving	previous learning
5: Assist in the use and organization of learning objects	The use of learning objects is central to the performance of learning activities, and the organisation of learning objects is a central function for a learning organiser system	<ul style="list-style-type: none"> Organise digital learning objects by context of use, associate objects with relevant learning events and with relevant knowledge
6: Adapt functionality to suit learning context, by monitoring and reflecting on: time information, the physical setting, the social setting, learning objects, information accessed for later retrieval, knowledge gain, practical outcomes and reflections, and the learning activities performed during a learning event	Context plays an important role in organising learning, since it is by spatial, temporal and thematic context proximity that learning activities, episodes and projects are grouped together	<ul style="list-style-type: none"> Time-tag learning projects, episodes and activities Location-tag learning projects, episodes, and activities Track the presence of other people during episodes Track the use of learning objects within activities Store learning objects with their contents Concentrate on knowledge gain: use concept maps to allow learner to record and maintain their knowledge gains over learning episodes and activities Provide a timeline representation of activities within episode indicating start, end, type of activity, and matching to relevant objects and knowledge

Figure 1 presents the main components of the system: (a) the projects and episodes timeline component, (b) the activity performance, capture and retrieval component, and (c) the concept map-based note-taking component. Component (a) utilises the timeline metaphor (Plaisant *et al.* 1998; Plaisant *et al.* 1999) to represent information about learning projects and episodes. A timeline affords traversing time backwards and forwards, and zooming to change the detail of time shown (for example, hourly, daily, monthly, yearly, etc. views). In KLeOS, projects are represented as lines in a project lines area, parallel to a timeline, and related episodes appear as vertical marks on the respective project line at appropriate time locations (for details see Figure 2).

Component (b) offers a learning environment where the user can perform learning activities (such as reading, writing, discussing and searching), where each activity is associated with a learning episode (and consequently a learning project) and involves the use of learning objects ('document') and the creation of notes about what is being learnt. While the learner uses this learning environment, the system is capturing the performance of activities, the associated documents used, and the created notes. The learning environment thus consists of buttons to invoke different activities and select the document to work with; a document area; a documents list; a notes list; and a timeline of activities performed within the current episode (for details see Figure 3). These lists are updated automatically as information is recorded while the user proceeds with their learning, reading different documents and making notes.

Note-taking is served by component (c), which enables users to make notes of the knowledge they gain on a Basic Concept Mapping Tool (see Figure 4). Concepts are recorded as chunks of text in a box (node) and are placed on a 2-D map at a location decided by the user. Relationships between concepts are captured as labelled links between the nodes, and both nodes and the links between them can be edited / deleted. Nodes may be added to the map whilst the user is undertaking a new, or revisiting a past activity. When creating a new node in the map, information about that activity is stored along with the node itself, and this information is maintained when the user later edits that node during subsequent activities.



(a) Project – episode timelines

(b) Activity performance, capture and retrieval

(c) Concept-mapping note tool

Figure 1: KLeOS structure

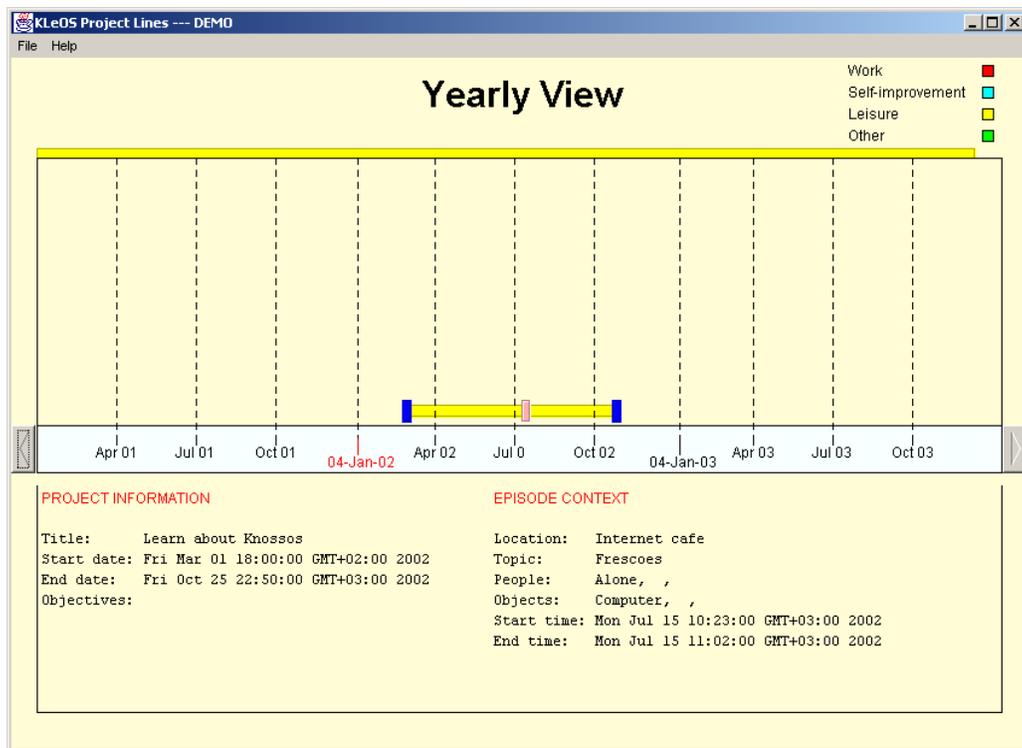


Figure 2: Project Timelines

KLeOS provides a bridge between the practice of learning (activity-episode-project hierarchy) and the external representation of the cognitive outcomes of learning (concept map), by automatically associating a note with the

activity context in which it was created. Thus, nodes in the concept map are tagged with information about the learning activity the user was performing at the time of note-taking; while each learning activity is annotated with a list of notes created in the concept map during the activity. The user can thus review previously recorded projects, episodes, activities, documents and notes. Retrieval can start either at the projects-episodes timeline, which the user can transverse until they locate the related episode and bring up its activity performance context (i.e. component b); or it can start in the concept map which the user visually explores to locate related notes and from there trace back the activity-episode context during which that note was made, review the relevant document, see the list of relevant notes, and perhaps from there jump to a different part of the concept map.

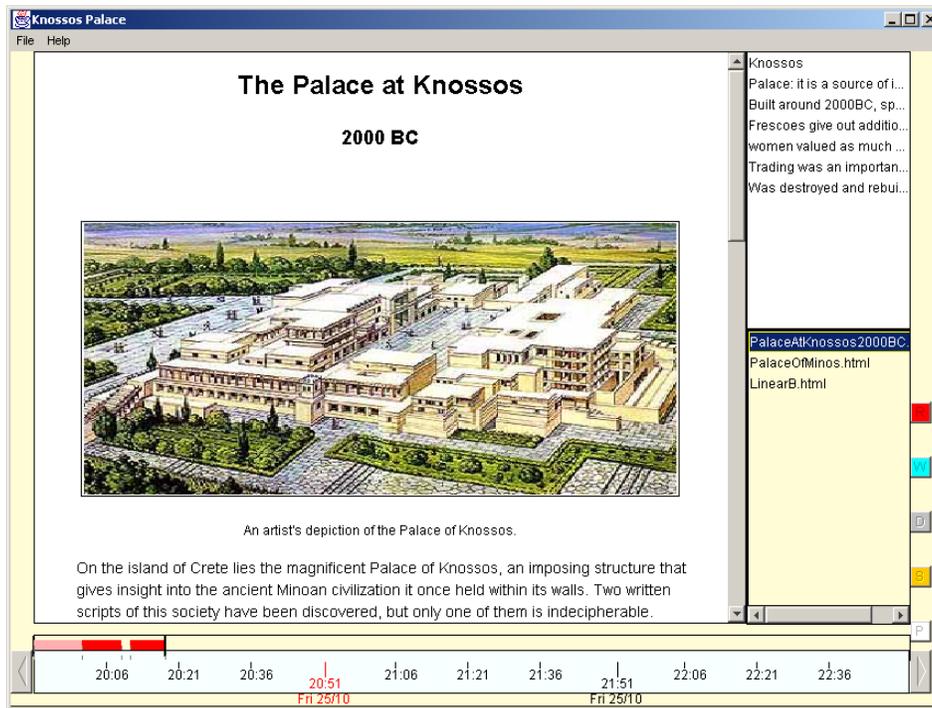


Figure 3: Capturing learning in KLeOS

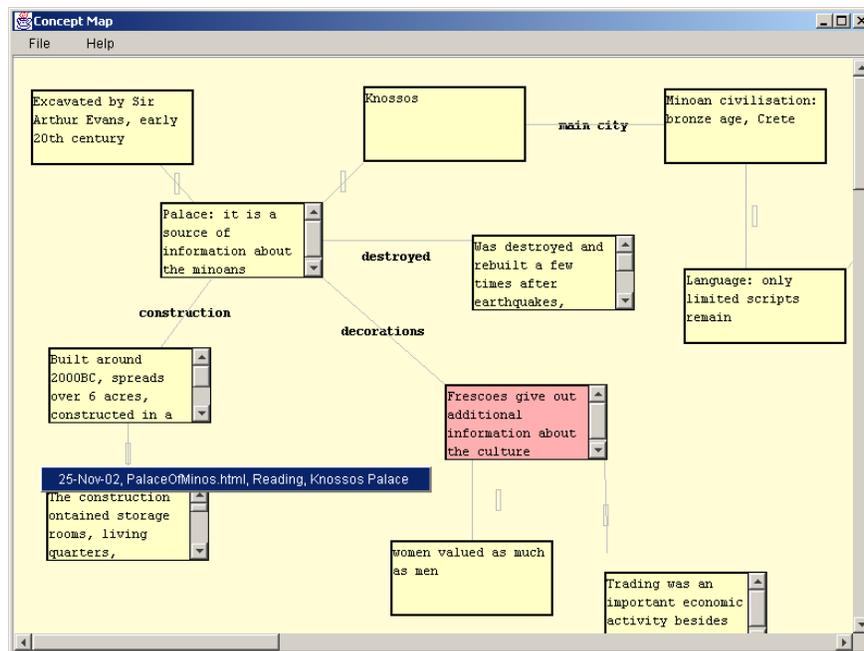


Figure 4: Basic Concept Mapping Tool

Evaluation of KLeOS

Product Reaction Cards

We assessed the overall user acceptance and desirability of the system using Product Reaction Cards, which are part of the Desirability Toolkit and provide a way of measuring intangible aspects of the user experience quickly and easily in the lab (Benedek & Miner 2002). Participants are given 118 cards with words or short phrases printed on them. The set contains 60% positive and 40% negative/neutral cards. The participants are asked to start by going through all the cards and selecting those they think best describe the system, or how they felt while using it. The cards they have selected are then recorded and participants are asked to select the five they think contain the most representative descriptions and justify their choices.

Fourteen postgraduate students/researchers with an interest in educational technology and of varying backgrounds (computer science, psychology, engineering, management, literature) took part in the evaluation. More than half the participants shortlisted the cards ‘usable’, ‘understandable’, ‘useful’, ‘organized’, ‘helpful’, ‘effective’, ‘easy to use’, ‘straight forward’, ‘time-saving’, ‘novel’, ‘engaging’ and ‘clear’. More than half the participants also found the system ‘slow’, referring to instabilities of the current implementation rather than the LLO concept itself.

The general concept seems to have induced positive feelings in the users, with a number of them indicating that they consider it a valuable learning tool:

“Memory is extremely important and improving ways in which information can be acquired, stored and retrieved are increasingly necessary as the complexity of subjects rises. Students complain about not being able to use their time effectively, I think that, with a few refinements, this sort of tool could be extremely useful” (male, 28, research student),

“I felt it would be a very valuable resource, in terms of helping me organise a large body of information” (female, 26, research student),

“I liked the fact it was my personal record, I could see when I looked at a document, the notes I’d made and how I felt these notes related to other ideas. I felt a certain sense of ownership which was reassuring.” (female, 34, research student).

Usability Evaluations

KLeOS features were evaluated via a questionnaire for their perceived usefulness, appeal, and utility as learning recall aids, following a 60-minute lab-based learning task and a follow-up revision session two weeks later. The Basic Concept Mapping Tool, Notes List, and the individual episodes recorded for each project were voted as most useful; the Activity Lines and the ability to pause learning were thought the least useful.

The list of features that the participants were asked to rate with regard to their utility as learning recall aids also included the participant’s own memory as a comparison measure. The Documents List and the Concept Map scored better than the participants’ own memory, indicating that the participants regarded the collections of their learning documents and their notes as significant recall aids – this is not surprising, given the extent of archival of learning objects and personal notes learners usually do. The Concepts List did not score as high although it was identified as a useful feature. The Activity Timelines were not thought to be of help as recall aids, which may be an indication against the presumed linearity in the performance of learning activities.

The most appealing features were the Basic Concept Mapping Tool, followed by the linking between documents, activities and relevant notes, and the Documents List. Attributes of the software such as its novelty, ease of use and simplicity were also mentioned. The least likeable features related mostly to aspects of the interface (like limited navigation and manipulation of concept map objects, the colours, shapes and general appearance of the interface, the slowness of screen refreshing, etc.).

Overall, the concept of KLeOS was well received, with 13 participants stating that they liked/appreciated the idea, and only one expressing a negative opinion. The perceived greatest advantages of the system were (a) the ability to keep a record of one's learning and revisit that record (mentioned seven times), (b) the ability to organise learning resources, knowledge, and relationships between them (mentioned six times), and (c) the simple and easy to use interface (mentioned three times). The perceived greatest disadvantages were (a) that it is time consuming to maintain, (b) it is not flexible enough (e.g. to accommodate learning material outside the computer), (c) the interface performance, (d) the lack of integration with other tools / technologies, (e) the lack of a text search facility, (f) the dependence on (generally unreliable) electronic devices, and (g) the danger of potentially reducing the amount of note-taking one does.

Additional requirements for LLOs

Reflecting on the design and evaluation of KLeOS, a number of additional requirements emerged. Table 3 lists these requirements and demonstrates how they relate to the design and evaluation findings.

Table 3: Additional requirements that emerged from reflections on KLeOS's design and evaluation findings

Requirement	Evaluation findings	Reflections on design
7. 'Sense' contextual information (e.g. continuous activity, topic/objectives contingency, fixed location, people, resources, location, and time) to automate as much of the monitoring as possible (e.g. automatic generation of project-episode-activity hierarchies), and thus keep maintenance times low.	a. High maintenance time	b. User should be able to start learning activities quickly, without the need to provide too many contextual details
8. Support all commonly performed learning activities (note-taking, discussions, problem solving and breakdown recovery, searching for information, receiving and providing help, reading, writing, reflection, planning and prioritisation).		a. The whole range of learning activities identified in the study must be supported
9. Adjust to user preferences by allowing the user to: 10. negotiate the level of granularity for the activities (e.g. an activity may consist of the processing of a single object or multiple objects, or the manipulation of a single object may be broken down into more than one activity) 11. work with their preferred (external) tools/applications 12. select their preferred representations for their sets of notes and documents (e.g. concept maps or linear text); and for their sets of activities, episodes and projects (e.g. timelines or calendars)	a. Lack of integration with other tools	b. Learner must have choice over interface metaphors (e.g. timelines) and external representations for notes/documents, based on personal styles

13. Provide search facilities that draw on both episodic and semantic memory, and on combinations of the two	a. Lack of text search	b. Learner must have other search options in addition to browsing-style exploration of past learning episodes and learned concepts
14. Implement on reliable technology with a ubiquitous user interface	a. Depends on reliability of digital technology b. Slow	c. Learner must be able to perform activities outside a specific application

An ideal LLO

The requirements discussed in the previous sections have helped us to create a vision for an ideal Lifelong Learning Organiser as a system that observes episodic learning context and how it is coupled with the scaffold of concepts and associations that constitutes the semantic learning context; creates records of it; and presents it back to the learner upon request for reflection and reuse. The ideal LLO is conceived as an alternative or add-on to the computer 'desktop' metaphor. Instead of (or as well as) associating electronic objects and documents with locations in folder hierarchies, the LLO associates them with the activity contexts in which they are used or created. The launching of applications used for various activities happens automatically, based on user-established associations between activities and applications. For example, a writing activity will launch Microsoft Word™, OpenOffice.org Writer™, or Windows® Notepad, depending on designated user preferences.

In the course of performing learning activities the person learns concepts and facts, and forms mental relations between them as well as relations to other pieces of knowledge that had been acquired in the past. In everyday life, these are often recorded as notes in various forms: concept maps, linear text, diagrams, document annotations such as highlighting, etc. To maximise the LLO's functionality, once encountering a new concept the learner would make a note about it. The LLO, by applying automatic text processing techniques can identify the topic of the learning and retrieve a relevant notes document. The learner is able to form links between different portions of the notes document as well as across documents to represent knowledge interconnections. The LLO could also automatically linearise a network of notes, presenting its semantic associations as narrative text, based not on the order in which the notes were taken, but on the strongest chain of semantic associations between them (see Sharples *et al.* 1994 for an algorithm to automatically linearise notes networks).

The monitoring and recording is transparent, taking place in the background: the system does not interfere with the learning, nor does it force the learner to diverge from their learning 'rituals'. Rather, it is silently taking note of what happens. In its simplest form, the LLO logs what activities the learner selects, the objects they manipulate, any notes made during the activity, and the location and time of learning (e.g. employing positioning systems and time-stamps). A more advanced system will additionally employ artificial intelligence techniques, automatic text processing, speech recognition, intelligent sensors and related technologies to infer what they are learning about, who they are learning with, what they want to achieve, and what overarching project and other episodes the learning relates to (Chen & Kotz 2000 see for example ; Lamming & Flynn 1994; Rhodes 1997; Salton 1988). Of course the user can at any point override or delete the automatically created links, or can add new links, at will.

The ideal LLO incorporates a project organisation review interface, which enables the user to have an overview of their learning projects over any given period of time, by providing at a glance details about the number of projects, the topics they relate to, and related past and planned learning episodes. The user can either have a full view of all the projects in a given period, or apply suitable filters. The user can choose to review specific learning episodes: the episode's contextual information (people involved, location, etc.), the activities that they performed and the objects they used. Filtering of episodes is also possible, for example by specifying certain episode context parameters (e.g. display episodes that involve a specific person).

Text searches are possible, both on notes documents and on the space of projects, episodes and activities, allowing the user to arrive at specific pieces of information directly, without any need for navigating within their personal learning history. Note, however, that for text searches to work the user needs to remember what they know – whereas

the advantage of associative retrieval through such navigation is that the user has the ability to recall knowledge and resources that they no longer remember they possess.

Discussion

The concept of LLOs as sketched by the identified requirements has many parallels and connections with Learning Organisation Information Systems (LOIS), with Personal Information Management systems (PIMs), and with e-Portfolios. LOIS (Williamson & Iliopoulos 2001) target the learning of organisations and require the ubiquitous capture and documentation of learning through normal work and learning practices; and also require easy, just-in-time retrieval of that learning. PIMs are event-based personal information retrieval systems (Bovey 1996; Chalmers *et al.* 1998; Eldridge *et al.* 1992; Freeman & Gelernter 1996; Lamming & Flynn 1994; Lamming & Newman 1991; Lansdale & Edmonds 1992; Plaisant *et al.* 1998; Yiu *et al.* 1997) that utilise episodic context for the retrieval of personal information resources and content. e-Portfolios enable the management of digitised collections of learner-created artefacts and their sharing with others (Lorenzo & Ittelson 2005). We should emphasise the need for synergy between these types of tools, to enable not only the private organisation of personal learning and knowledge, but also its (formal or informal) sharing within a learning community.

Concepts similar to those described above as part of LLOs are being incorporated in a file system and interface for the One Laptop per Child (OLPC) project (<http://www.laptop.org>), whose mission is to develop a low-cost laptop (the \$100 laptop) for children in developing nations (OLPC 2007). The OLPC interface is based on the concept of 'activities' that pupils can perform and record in a 'journal'. Starting in a 'home' page, where active and recently publicised activities are listed, the student can resume an activity, join or offer to share activities, or start a new one. The OLPC interface, like the LLO, intends to replace the desktop metaphor with an activity-based interface that takes the focus away from 'things' saved in files and folder hierarchies, to 'things' done in the course of learning.

The LLO concept brings up a number of issues in need of further investigation. An important issue for all life-logging applications is whether the revisiting and revision of a captured episode constitutes a new episode in itself. In the context of an LLO the question translates to whether the learning log should be extended to include a new entry about the revision of a past entry. Or whether the revising should result in the modification of a past entry, in which case versioning of learning log entries may be appropriate. Another related issue is whether the user should be allowed to delete past log entries. Beyond the technical aspects of these issues, the underlying question is how do learners want to recall their past? Are they likely to want to forget learning episodes at will, or to alter their memories? Research suggests that experience can transform memories (Greenhoot 2000); whether the moment of memory transformation constitutes a memorable learning event in its own right needs further clarification.

Although LLOs are envisioned to support the creation of external representations of semantic context and their interrelating with episodic context, it is not clear how the process of restructuring our semantic associations to fit newly learned concepts within a specific episodic context actually takes place: how does the process of abstraction work and how can LLOs best assist it are questions for future research.

The recording and storing of personal information by LLOs bring forth issues of privacy: do learners want to share their records of learning experience? With whom – teachers, peers, colleagues? Who owns the shared records of experience – the teacher? The student? The employer? In KLeOS all the captured data is for personal use only and is not meant to be any more shareable than the user's non-captured learning memories. However, issues of privacy, ownership and security of data need to be resolved when designing systems that aim to store personal information over a lifetime, giving the user/learner control over how the information is gathered, who it is presented to and in what form (see for example Schreck 2003 for an analysis of privacy and security requirements in user modelling).

Storing information over long periods of time also brings up technical issues related to data compatibility and persistence – for example, changing legacy formats supported by word processors may render old electronic documents unreadable. Although standards such as ASCII have survived since the 1960s, and backward compatibility with such 'core' standards for public data archiving is generally well supported, the preservation and maintenance of data that is usable throughout a lifetime is an important technical concern in the design of LLOs.

People's ability to recall some episodes more easily than others is also a factor that needs to be considered. Some of the life-logging projects mentioned previously in the paper address this through algorithms that calculate the memorability of a certain event in terms of its distinctiveness: episodes that are not repetitive, or that take place in unusual social, physical, or technical context, are more likely to stand out in a person's memory compared with more routine episodes (see for example Horvitz *et al.* 2004). This may affect the extent to which episodic memory will be useful in recall. To an extent, the LLO's ability to combine episodic and semantic memories may be the answer to such limitations of episodic memory; however, thorough evaluations of LLOs are necessary to assess this effect.

Evaluation of LLOs is itself a challenging area. LLOs are designed to be used as part of the learner's everyday learning practice, and they offer facilities to access materials and to make notes for topics that are of genuine interest to the learner as well as to retrieve past knowledge and materials for personal use over a lifetime. In contrast, the evaluation presented in this paper was based on an artificial, externally imposed, time-bound learning task that was not necessarily meaningful for the learners, and the knowledge retrieval context was not necessarily relevant to the learners. Moreover, a 60-minute learning episode like the one that was the context for the evaluation is not an ideal way to capture the way episodic memory works: the experiment involved a singular learning task which is likely to stand out in participants' memory, with an internal structure that does not encourage multiple representations in episodic memory. A final shortcoming has been the small number of participants and their background and enthusiasm for both IT and educational technology. Although a knowledgeable group like this can be an advantage in formative usability evaluations like those reported in this paper, at the same time it makes generalisations to other groups or types of learners difficult. We will thus reiterate Lansdale and Edmonds' (1992) argument that longitudinal, *in-situ* studies are necessary for the evaluation of this genre of tools.

Conclusions

In the above we have presented the concept of Lifelong Learning Organisers (LLOs). We have documented the need for LLOs through an empirical study of the everyday learning practice, and have drawn an initial list of general requirements for LLOs based on the empirical study, the design of the KLeOS prototype, and its evaluation. Based on the requirements, an ideal LLO would be a system that quietly sits in the learning background, capturing learning activities, episodes and projects as well as the learner's personal notes, extrapolates relations between the captured items, and allows the learner to retrieve the captured content as necessary in the future, through retrieval mechanisms that are based on episodic memory, semantic memory, and free-text searches.

We propose LLO-type tools for an emerging learning society the citizens of which need to be continuously (re)learning in order to fully exploit the learning opportunities on offer for their personal development, fulfillment and enjoyment. We view the deployment of such tools not as the end point, but rather the starting point for more, and exciting research: tools are designed to aid practice, but tools also change and affect practice. Often the way people adopt a piece of technology is not the same way that the designers expected. New tools that enable self-directed learners to organise their learning experiences, resources and knowledge in new ways may transform the way they perceive and practise learning.

Acknowledgements

The material in this paper is based on the first author's PhD thesis, supervised by the second author, while at the University of Birmingham, UK.

We thank all the study participants for giving up their time to keep diaries, attend interviews, fill in questionnaires, and take part in lab trials.

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