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Learning Objects and Their Implications on Learning: a Case of Developing the Foundation for a new Knowledge Infra-structure

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Introduction

In a global, knowledge-driven society, the need for job mobility and for reskilling to match developments in workplace technologies, have led to a requirement that we embrace lifelong learning (Gibbons et al 1994). In these conditions, people require continuous access to learning-objects and an ever-expanding market has developed in response to provide them. Users today can find an overwhelming abundance of available resources. However, locating amongst these any which are relevant could prove a very difficult task indeed.

Moreover, we live under conditions of continuous and rapid change – whether driven by technology, by fashion or by necessity of mobility. In this context we know that needs of learners may well be very different tomorrow from those supported by systems of today. It is a matter of great importance therefore that modern knowledge infrastructures are designed with principles in mind that will allow them to survive and adapt to changing needs, and the ever-increasing volume of available learning-objects.

A major problem confronting users of learning-objects is how to search effectively for those which are relevant to the context of their needs. Traditionally, dealing with a large volume of potentially useful objects requires users to recognize *which* relevant search phrases to use and *how* to ask relevant questions. These very particular competencies are unique to each user, and will inevitably affect the outcome of the search/interaction process with the object in which the user is interested. In considering this problem, there is an imperative to differentiate between *user needs* – perceptions and understandings which we can never extract from inside of user heads and user experience – and *descriptions*, texts and data which could be used to create re-interpreted models of user needs. Such models might be found to have some utility, and also some experienced validity, for individuals. Some recognized relationship between interpreted

and experienced user needs may be hoped for, and it is this relationship which could form the basis for development of supportive services.

A further dimension is the increasingly varied range of access capabilities available to a user. We have entered an age of ubiquitous computing, where users may be attempting to search through a wide range of devices, from traditional desktop PC's while at work, to portable PDA's and smart phones while on the move, to iDTV's while in the comfort of their home. As ubiquitous and pervasive computing develops, we will find that searching via an ever-increasing range of devices will become common. Just as it is now possible to buy a fridge with embedded processors which will tell us when we are out of milk, perhaps the desk or armchair of the future may be embedded with the potential to search for information or learning-objects. As this range increases, so does the complexity of systems, which must be adapted in order to provide a personalized access route to learning-objects. A customized approach might provide an ad hoc solution, perfectly meeting an individual's need. However, this would be a static solution to a complex and on-going problem, and still presupposes that users have the right technical equipment, know how to use it and know how to perform a 'perfect' search.

A number of substantial research projects have taken place in recent years (in partnership between a range of significant European industrial actors and academic institutions) which have explored the possibilities of establishing usable infrastructures (EASEL 2002, Foster et al 2002, GUARDIANS 2002). Selected findings from these projects are described below. We aim, in this Chapter, to draw on experiences and lessons learnt from such recent developments in advanced information systems, but we will examine them in conjunction with contemporary research into individual requirements shaping (Bednar 2000). We will suggest a new model for developing an infrastructure, reflecting the importance of flexibility and adaptability to change. Importantly, our model will also address the possibility for symmetrical control of inquiry between learner and provider of learning objects.

Background

In this section an overview is given of recent key research projects – RENAISSANCE, EASEL, GESTALT, GUARDIANS and a short description of the activities of the MRU.

RENAISSANCE

This projects stands for Integration of High Performance Services for Interactive Vocational Training for European Regeneration. The aim of the RENAISSANCE project was to demonstrate the capabilities of high performance broadband digital networks to deliver long-distance virtual vocational training. To this aim, the RENAISSANCE project has developed a virtual vocational training environment to deliver multimedia content to 5 SME communities across Europe. The training material used for the trial has been developed for the Networking and Music industries, for the requirements they provide regarding bandwidth, synchronization and quality of service. The training has been delivery over an integrated broadband digital network including ATM, CATV and ISDN technologies spanning several countries across Europe.

The primary theme of the project has been integration of broadband ATM and CATV network and service technologies with a view to explore the grounds for a viable service delivery business model, not only independent of bearers and components, but also capable of interoperability across technology boundaries. However, the project experienced internetworking problems relating to the establishment of the networking infrastructure. Thus it was difficult to ensure the availability and smooth operation of the ATM, CATV and ISDN local and remote interconnections. Although the various technologies were successfully integrated for the project trials, it became clear that the availability of the prevailing technologies in Europe was not to be taken for granted and they certainly needed a lot of testing and evaluation before they become widely available for educational purposes.

Numerous user trials were run during the project, both at local institutions and across the European network test-bed, in order to evaluate the Learning Environment developed for efficiency, effectiveness and usability.

EASEL

Educator Access to Services in the Electronic Landscape (EASEL) was funded under the European Union 5th IST Framework, the EASEL project explores technologies which can be integrated to offer course constructors an environment to create new on-line educational offerings. Specifically, the EASEL goals were to explore technologies to offer educators:

- the opportunity to search, locate and access existing courseware.
- the opportunity to configure new course offerings reusing discovered material.

The figure below shows an overview of the architecture of the EASEL system. Here we can clearly identify a number of metadata repositories where learning resources are described. The approach followed in EASEL is to adopt a number of different standard metadata models to describe resources. These are the IEEE LOM, the IMS metadata and the Dublin Core Metadata Element Set (DCMES).
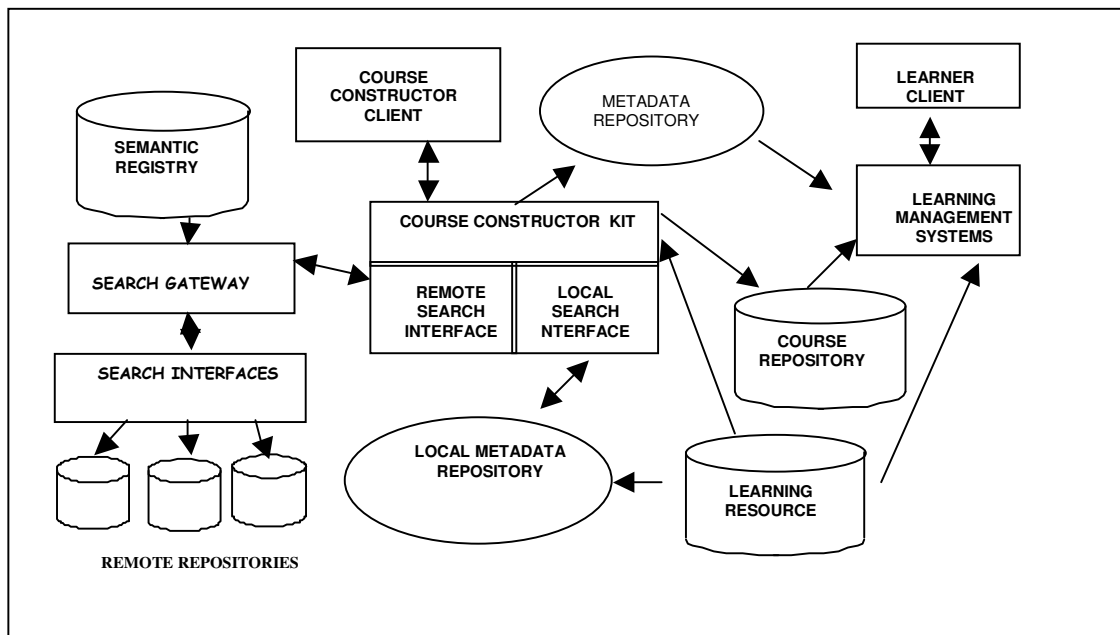
Fig.1 EASEL

A single data model is in fact not realistic since different organizations or communities define their own schemas and taxonomies that are only applicable to their resources. Each organization keeps a local repository which stores metadata created according to the organization preferred standard and can search also across remote repositories which adopt different and even unknown metadata schemas. One of the main components of the architecture is the Course Constructor Kit (CCK), which is a tool for constructing learning modules, to be delivered as part of a general programme of learning and offered to students enrolled on that programme. The CCK allows modules to be constructed from a wide range of resources, both owned by the institution and available remotely over the Internet.

GESTALT

Getting Education Systems Talking across Leading-Edge Technologies (GESTALT). Within the European Union 4th Framework Programme, the project GESTALT has addressed the issues related to the support of on-line discovery and delivery of digital educational resources through the web. The project has also addressed QoS, client configuration and rendering requirements for online distance education resources through the specification of bearer-service network independent metadata extensions. The GESTALT architecture depicted in the figure below leverages on the results of other research projects such as RENAISSANCE.

Bednar, P M, Welch, C and Graziano, A (2007) 'Learning Objects and their implications on Learning: a case of developing the foundation for a new Knowledge Infrastructure,' Chapter 6 in '*Learning Objects: Applications, Implications & Future Directions*'. Harman, K and Koohang, A, eds., Informing Science Press, NY, pp 157-185, ISBN: 83-922337-8-6. [final draft page no:4/21]
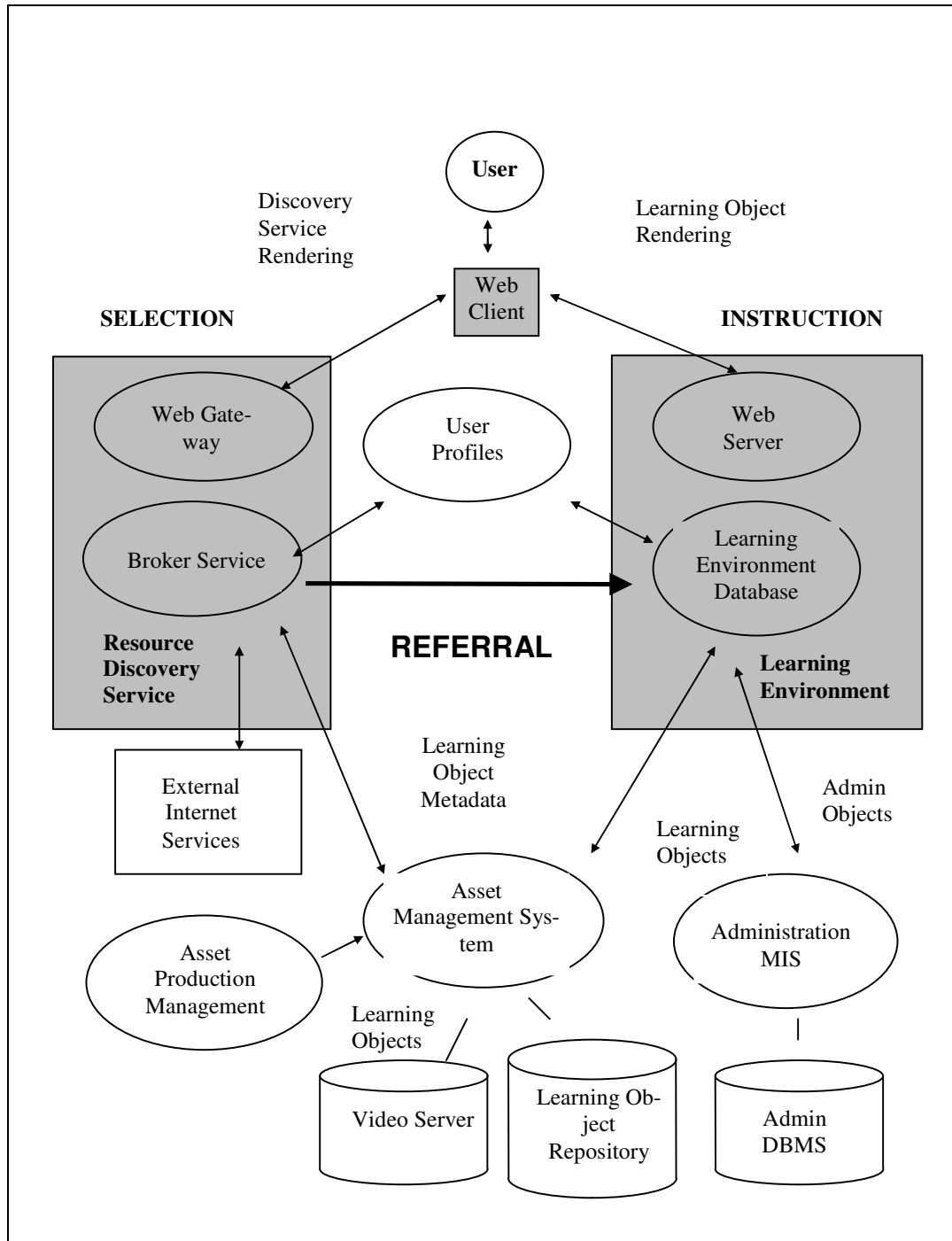
Fig. 2 GESTALT

Work in GESTALT has focused on developing a standard-based metadata model which would greatly enhance resource discovery services and interoperability between web-based learning systems. The complete GESTALT data model comprises the following components:

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- Courseware Content (GEMSTONES).
- Student Profiling/Tracking (PAPI/EPAPI).
- Curriculum Management (UOM).

The design of the three data models has drawn upon the work of a number of standardization activities in the field of metadata for education. Attention has focused on the work done by the IEEE LTSC, the IMS project, the ARIADNE project and the Dublin Core. One of the main achievements of the project has been to show the usefulness of metadata for enabling effective resource discovery services and QoS-enabled delivery. Although performed on a limited subset of metadata elements, results have been positive and therefore encouraging. The Metadata model developed has contributed to the standard IEEE LOM.

GUARDIANS

Gateway for User Access to Remote Distributed Information And Network Services (GE-STALT) addresses issues related to the support of on-line discovery and delivery of digital information objects over platforms such as the web and iDTV (interactive Digital Television). The application domain chosen for the experimental part of the project is the educational domain. The project consortium includes both academic and industrial partners from Italy, United Kingdom, Ireland and Greece. GUARDIANS has defined and experimented with an advanced service architecture for the management and delivery of digital information. The architecture (figure below) gives users access to a wide range of distributed information, which can be delivered to diverse media devices such as a personal computer and iDTV. In order to describe the information available to the end user, GUARDIANS introduces the concept of information objects, which are not necessarily learning domain objects but more generic electronic content deliverable through several possible channels.

Fig. 3 GUARDIANS

Bednar, P M, Welch, C and Graziano, A (2007) 'Learning Objects and their implications on Learning: a case of developing the foundation for a new Knowledge Infrastructure,' Chapter 6 in '*Learning Objects: Applications, Implications & Future Directions*'. Harman, K and Koohang, A, eds., Informing Science Press, NY, pp 157-185, ISBN: 83-922337-8-6. [final draft page no:6/21]
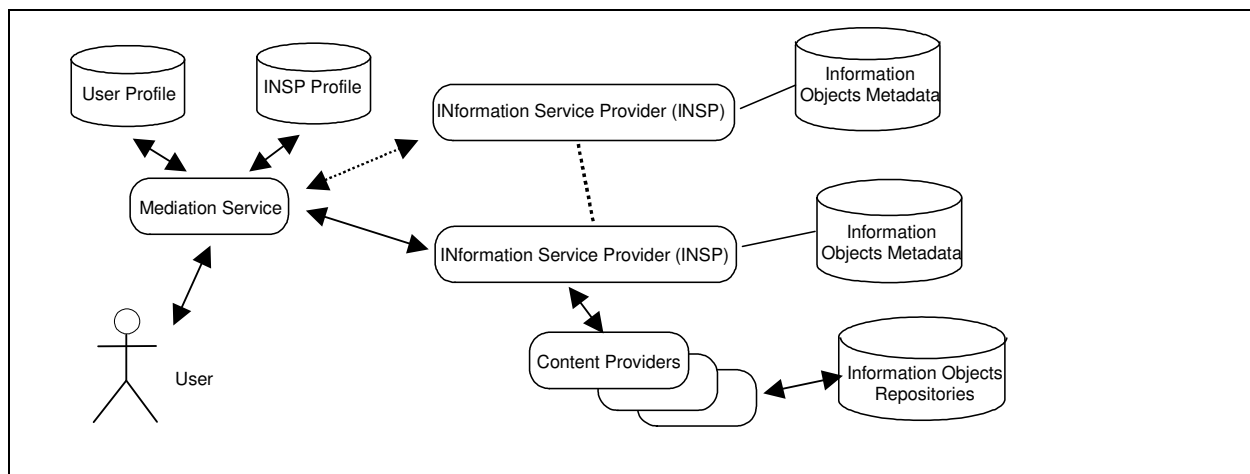
The GUARDIANS architecture builds upon the results generated by the GESTALT project, which has defined a flexible, component-based architecture for the discovery and delivery of modular training and education services. It further extends the metadata model to provide for the description of (information) service providers. One of the main success factors of the GUARDIANS project has been the development of prototypal iDTV Learning Environment, fully integrated with the proposed architecture.

MRU

The Methodology Research Unit (MRU) was initiated during the late 1990's in a collaboration involving Sheffield Hallam University in the UK and Lund University in Sweden. One of its major areas of interest was to be the study and enhancement of the philosophy, nature and content of a 'soft' information systems methodology and its applications.

The overall intention was to critically evaluate (information) systems approaches in a variety of problem contexts and to help enhance features and method content to address generic issues relevant to such environments. The MRU has supported a number of specific research initiatives. Three relevant examples of ongoing research are: the Requirement Shaping (RS) programme, the framework for Strategic Systemic Thinking (SST) and the research in Contextual Analysis (CA). All three are focusing upon critical systems thinking, incorporating practice with theory.

The RS programme is about enabling support for ICT (information and communication technology) enhancement of small and medium sized businesses, especially for client controlled development of business related ICT, network and online environment. At its best, the term 'requirements analysis' may incorporate most of the activities hoped to be denoted by the term 'requirement shaping'. However, in some settings, the term 'requirements analysis' may presume the prior existence of some 'requirements' that are to be 'found' or 'elicited'. The objective in coining the term requirement shaping was to avoid this narrow interpretation of requirements analysis.

Research in Contextual Analysis can be viewed as a feasible alternative in Information Systems Development which includes testing some of the surfacing pre-assumptions through a well defined programme. It is to be clear that this is not only an effort and argument based on induction from data to hypothesis; nor is it limited to deduction. It is even more focused on a critical analysis and testing of hypotheses against 'knowledge' by a process of abduction derived from some of the fundamentals of science and philosophy which are occasionally represented within the IS research field (e.g. Alvesson & Skoldberg, 2000).

One example of effort to support Contextual Analysis in practice is the SST (Strategic Systemic Thinking) Framework (Bednar, 2000; Bednar & Bisset, 2001), which supports systemic inquiry into a collective problem space from each individual participant's unique point of view.

Systemic thinking allows a problem space to be viewed holistically, in order to consider patterns of change and inter-relationships, and to access the level of complexity required to achieve understanding. The framework for Strategic Systemic Thinking (SST) provides a method for investigating perceptions and goals, and identifying missing resources. It assists users in posing possible solutions drawing upon their own understanding of a problem space. Users may be assisted in

the contextually relevant application of techniques such as brainstorming and drawing of rich pictures, as useful 'methods' for analysis. SST supports adaptation of methods to focus upon contextually dependant problems. The main parts of the SST framework are Intra-analysis, with individual focus, Inter-analysis with organizational or 'group' focus and Evaluation, focusing on assessment of conclusions.

SST is a systematic framework for systemic analysis. Multiple levels of analysis can be associated with the different orders of learning as described by Gregory Bateson (1972). A perspective based in Critical Realism gives the opportunity to consider both the reality of the natural world in the context of events, and discourses of a social world (Bednar & Green, 2004).

Systemic Models and the Role of Superinformation

As has been seen, infrastructures supporting searches for learning-objects will need to be flexible and adaptable to change. However, whilst accessibility and ease of use are important, we would argue that an approach of simplification would be misguided and that a systemic 'complexification' is required in development of infrastructures.

Information systems have a function of providing support to people taking purposeful action (Checkland & Holwell 1998, p.110). As such, any IS may be usefully viewed as entailing two linked systems: there is a system to be served and a serving system. It is suggested therefore that development of useful infrastructures requires that careful consideration is given both to the nature of the system served (in this case relating to learners or their agents, who have a need to search) and to the serving system (here, support for users in their searches for relevant learning-objects) (Checkland, 1981).

A system whose purpose is to support searching for learning-objects may be considered to contain within its boundary a communication sub-system to manage the way in which messages are being requested/delivered – how, where, from whom, etc. Effective searching via this sub-system can only be possible, however, when a further element is included which can help to identify the nature of available objects to the searcher. If a person chooses a book from a library, s/he refers to the details of author and title on the cover. Often, these minimal details are insufficient to support a meaningful choice, and the reader looks for a synopsis and/or reviews appearing on the jacket or flyleaf. In just the same way, someone looking for learning-objects is likely to need access to 'superinformation' to help in identifying those objects among many which may be best suited to his/her needs.

In the context of lifelong learning, the system to be served may be viewed as open and autonomous. In early stages, learning may take place in the context of a system which is open, i.e. interactive with its environment, but in which control is exercised through the decisions of 'experts'. At the more advanced stages, however, an approach to learning which is Socratic may become appropriate. Socratic learning requires that a learner actively engages in critical thinking, to address questions which examine the validity of an opinion or belief (Brown and Atkins 1991). In this context, subject problem spaces become more complex and any decision related to relevance of inquiry about learning-objects properly rests with the learner. Without access to rich

contextual material (in addition to content) autonomy cannot be achieved as the learner will not be in a position to make responsible judgments about usefulness. Complexity arises because the needs of the individual are neither constant nor given, but created through a process of continual and contextual rediscovery. At the same time, sources and availability of objects through the communication sub-system are subject to continuous change and growth. In order for Socratic learning to be supported, superinformation, generated by both searchers and providers, is exchanged. Negotiation and re-negotiation is therefore constantly taking place within and between the elements of the serving system and the system to be served, in a complex and dynamic, contextually-driven dialogue.

Within the field of information systems, no universal agreement has been reached on a definition of 'information'. There are several contradictory and competing alternatives (Callaos & Callaos, 2002). Two major different ways of looking at 'information' are as follows. In the first view, information is objective – i.e. efforts are made to express and document 'information' and 'knowledge' by individuals to inform others and themselves about 'meanings'. These may consist of anything externally recognizable through our senses as 'information'. It is this objectified view of information which we are referring to here in our discussion of 'learning-objects'.

An alternative view regards information as subjective in the way it is perceived and experienced. This is shown through the infological equation (Langefors, 1966) "$I=i(D,S,t)$". Meaningful information (I) may be constructed from the data (D) in the light of participants' pre-knowledge (S) by an interpretive process (i) during the time interval (t). The necessary pre-knowledge (s) is generated through the entire previous life experience of the individual. 'Meaning' is contextually constructed and attributed by individuals themselves through sense-making processes (see e.g. Weick, 1995, or Seely Brown and Duguid, 2002 p.133). These user-constructs cannot be perceived directly by an observer, but can be explored through inquiries into individual sense-making, which in turn are related to a multitude of contextual dependencies (Bednar & Mallalieu, 2001). It is in this sense which we are using the term when we refer here to 'superinformation'.

By analogy, if we follow these distinct views in relation to learning-objects, an ICT learning package on a CD, for instance, is an object, whereas the 'understanding' constructed by the user in going through this learning material constitutes information or 'knowledge' . The former is objectified and 'unchangeable'; the latter is subjective, contextually constructed and variable.

Reflecting on the role of information in learning, Seeley Brown and Duguid (op cit) call upon Gregory Bateson's idea of a 'difference that makes a difference'. (Bateson, 1972). If attribution of meaning can be viewed as a change in a system which was previously in a stable state (like the ripple formed when a pebble falls into a lake), then it is as important to appreciate the original state as the new one.

"*The background has to be in place for the information to register. The forces that shape the background are, rather, the tectonic social forces, always at work, within which and against which individuals configure their identity. These create not only grounds for reception, but grounds for interpretation, judgment, and understanding.*"

(Seeley Brown and Duguid, op cit, p.139).

Over the last decade, researchers and developers have acknowledged the key role of metadata for the purpose of information-object retrieval and delivery. Metadata has been defined as 'data about data', and includes data associated with an object for purposes of description, administration, legal requirements, technical functionality, use and usage, and preservation (Baca, 2000). Metadata are designed to help in the process of identifying relevant or appropriate objects. Attempts have been made to establish standards for metadata structures in relation to learning-objects, e.g. a standards committee of the IEEE, the Learning Technologies Standards Committee, has set out a model defining over 50 elements in a hierarchical metadata structure, including title, language, rights management and description (LTSC, 2005). However, these are focused on the purely instrumental issues of cataloguing and description. The context of educational use is largely ignored.

As demonstrated above, from a user view, superinformation is needed to convey descriptions of contextual dependencies, so that more informed decisions can be made in selection of learning-objects. This superinformation could relate to validity, reliability, or political purpose etc – 'hidden' contextual dependencies belonging to the 'origin' of an object. The issues here are both how to identify, and what to include in, additional descriptions. Can metadata be used successfully to supply this need? Is it possible to create and use metadata, which would allow a user, from his/her own point of view, to make a successful validation of objects? A relevant description of contextual dependencies cannot be just a value from a list in a metadata field. The meaning of context must be wider and richer than just an index, in order to allow a more qualitative description from (and about) the 'author' of each object. While use of metadata can facilitate retrieval of learning-objects, which would not normally have any textual representation (e.g. audio/visual resources), a proliferation of resource description models would tend to make a search process more difficult to deal with. Furthermore, efforts in relation to metadata tend to concentrate on the supply side of the negotiation. The role of superinformation in establishing user need profiles requires greater attention if supportive infrastructures are to be developed.

Reusability has been an issue of concern to developers and providers of learning-objects and is thus worthy of attention here. Modern political agendas often favor a personalized approach to education and learning It may be considered desirable for learning objects to be created once and used 'forever' – this promotes efficiency and avoids the waste of resources in 're-inventing the wheel'. In order to be reusable, learning-objects need to be created with a level of granularity to allow for fractioning and reuse. However, the more objects are fractioned, the more 'standardized' they become, and thus the less 'information' they contain. Some schools of thought favor breaking down learning-objects into bite-sized 'chunks'. However, opinions differ as to the proper place for contextualizing metadata. Should learning objectives, for instance, be embedded within the learning-object itself? Some would argue that this will enable learners to assess their current state of preparedness before embarking on a 'learning episode', whereas others would argue that there is a need for a narrative thread to create a coherent pathway of learner-centered objectives, which can only be created from beyond the objects themselves (Laurillard, 1993).

There appears to be an inherent conflict between a desire for efficiency and a need to empower users to search for contextually-relevant material. Furthermore, it should be recognized that the

source of relevant information may lie in the contextual interconnection between data items which defies attempts at standardization. Experience from the EASEL project shows that 'information reuse' is not always possible, nor desirable. Some information-objects will never be reusable in relation to an 'original' purpose. In the educational domain, users sometimes need to recreate information from 'scratch' even if they have some readily available resources. The perfect information retrieval system might allow us to find all the relevant objects, but it is unlikely that it will convince us to use it. If it is not inherently possible to validate a learning-object as reliable, reuse will be difficult and it may eventually be abandoned.

Experience from European projects has shown that contextually-relevant information could not be entirely standardized, and thus neither creation nor use of metadata could be fully automated. The approach followed in a metadata standardization process is to define a number of vocabularies and taxonomies to standardize a metadata population process and facilitate its automation. However, much of the significant, i.e. contextually dependent, description cannot be so easily classified. In a technical domain with boundaries which are relatively clear, there may be potential for the use of standardized metadata. (e.g. in the EASEL project, an example of searching for objects relevant to the teaching of JAVA was chosen). However, when an experiment was chosen in a field relating to the Humanities results were more problematic. This is because available descriptions regarding an information-object's purpose and background would be insufficient, and contexts such as environment and political history become essential.

We suggest that it would be both unfortunate and naive to believe that such contextual dependencies are unique to objects relating to subjects within the Humanities. Problems with generalizations, assumptions and prejudice are not unique to any particular field. In fact an inquiry into the 'unknown' is relevant in many fields - for example strategic planning in business, where competitive organizations must scan their environments in order to survive and prosper. We can recognize this in the focus there has been in recent years, in organizational and management research, on complex systems and chaos theory (examples can be found at the Center of Excellence in Complex Systems at the LSE, UK).

Nor is inquiry based simply on avoidance of difficulties, but also on a 'natural' human desire to enter and explore what is 'unknown' (Bednar & Mallalieu, 2001). In all such sense-making activities there is always a human meta-activity which, when consciously pursued, aims to evaluate the validity of underlying activities. This meta-activity is especially significant in the context of Socratic learning and requires significantly richer pictures and descriptions of contextual dependencies if learning-objects are to be experienced as reliable.

The prototyped service solutions from the described European projects have been seen to be successful in many ways, providing valuable support for educational purposes. However, it is clear that they are not yet built on a sufficiently dynamic model to be adaptable to more advanced and general user-needs. The core (and inherently problematic) issue remains of mapping between available metadata and metadata that are needed (for the creation of superinformation) to support users' sense-making processes. This is especially so since users may not be able to recognize what is needed. Any process of searching for contextually-relevant learning-objects must involve negotiations between the serving system and the system to be served, during which superinformation is created and recreated by diverse elements of both systems.

Systemic Models and the Role of Infrastructure

Users may desire a high quality service from learning-object infrastructure, but major difficulties could arise. It is difficult to imagine how a service would be able to develop or mediate missing descriptions of contextual dependencies. Drawing on the work of Grunig et al, (Grunig and Hunt, 1984, Grunig and Grunig, 1992) it is argued that a practical requirement of such mediation is a facility for two-way symmetrical communication with users.

Writing in the field of public relations, Grunig proposed four distinct models of communication, differing in two dimensions. The first dimension is *direction* – the extent to which the model is one-way or two-way. One-way communication disseminates information as a monologue. Two-way communication, on the other hand, exchanges information through a dialogue. The second dimension is *purpose,* which describes whether the model is symmetrical or asymmetrical. Asymmetrical communication is imbalanced: it leaves the originator of a message 'as is' and tries to influence the receiver. Symmetrical communication is balanced; it adjusts the relationship between originator and receiver (Grunig and Grunig, 1992, p. 289).

In Grunig's view (1992, p. 231) 'Symmetrical communication takes place through dialogue, negotiation, listening and conflict management rather than through persuasion, manipulation and the giving of orders'. Two-way symmetrical communication therefore includes 'listening' and changing boundaries of dialogue between originator and receiver – two way adaptation. The authors of this chapter would argue that contextual dependencies which influence information need can be mediated only through such a dialogue. If communication between user and system remains asymmetrical and/or one-way then the user is obliged to struggle alone with the full complexities of the search process.

Where the needs of a user are relatively simple, communication with a serving system might be viewed as a *transaction*. For example, if a person knows the name and address of a friend but not his telephone number, then he can call directory inquiries and obtain the necessary missing information-object. Two-way, symmetrical communication (dialogue) takes place, but the extent of the interaction is ephemeral and both parties rapidly discharge the extent of their interest. However, where negotiation and re-negotiation over exchange of superinformation are needed, as suggested above, the position is entirely different. Here, dialogue takes place in a protracted relationship between inquirer and service, giving rise to a need for more sophisticated networking and interaction management to be supported.

A related issue for the serving system is concerned with a possible proliferation of user profiles - those owned and controlled by individual users and their agents on one hand, and those owned and controlled by service providers on the other. A service model needs to address the ease with which the system to be served is enabled to develop superinformation about users and the context of their searching, e.g. mode of access. These details could be needed to populate different profiles for different service providers. Users will not want to fill in all their details every time they create a new profile, nor will they necessarily wish to share the same profile with every el-

ement in the serving system. Consideration must be given here to users' legal and ethical rights, including a right to access their individual user profiles, to restrict their use to defined purposes deemed to be appropriate, and to have a profile amended or deleted at will (Lynch, 1996).

When looking at the models for communication that, for example, the GUARDIANS and EASEL prototypes are built upon, we can see that in practice they do not consider a two-way symmetrical information exchange. Both models mainly consider a mediation service perspective (in this case a 'channel' perspective, not a fully developed 'sender' perspective). This means that the sender – receiver perspective is missing. It also means that the dialogue between source (the author of an object) and end user (the receiver of an object) is likely to be severely limited in practice. The GUARDIANS architecture can cope very well with personalization, especially device-wise at a technical user level. However, it does not support any sort of collaborative filtering work through which users can enrich their needs for qualitative validation. There is no way for users to have a constructive dialogue with the mediation service enabling negotiation to be supported over the 'rules of the game'.

Discussion of Implications

It is a challenge to develop an infrastructure for services to provide a bridge between users and providers. Three key issues emerge. First, where there are many learning-objects, how does a user find those, if any, which are most relevant to her/his needs? Secondly, how can we streamline a laborious process of finding relevant objects so that a system knows what users want, and can help them find future learning-objects? Thirdly, how can support be provided for delivery of learning-objects in a dynamic context of ubiquitous and pervasive computing?

Any model of an infrastructure for a serving system must allow for interactions between a number of stakeholders functioning within both the system to be served and the serving system:- learners or their agents, content/object creators and 'providers' – those who give access to the information and other information gateways, services or technologies.

There may be alternative stakeholders. Supermarkets, for example, might buy and sell complementary learning-objects. Another possible alternative could be 'third party' companies, selling intermediary services to support the user (e.g. step between the user and the 'gateway'). This would be analogous to the service provided by professional librarians when they search in online databases on a reader's behalf. In addition, software/hardware companies might develop support solutions to put more control in the hands of the user, e.g. intelligent software services or 'middleware'

As our earlier discussion of communication paradigms highlights, there is a need to consider the requirements for a future infrastructure that includes 'meta-level' communicational standards and protocols. It is no longer satisfactory to be able to access learning-objects, there is now recognition of a need for rethinking 'standards' and 'protocols' that can support access to 'relevant' objects. Problems that follow have to do not only with *definition* of superinformation but also with *validation* of 'relevance'. (See descriptions of projects above). Some of these problems are technical in the sense that presentation of any data has to be adapted to the particular technology that

is used. This would for example require translation frameworks and standards for data transfer and re-representation, e.g. web pages developed to be presented on a computer screen would need to be transformed to be usable via a mobile phone. Technological solutions that 'transform' web pages on the fly to a format that might be usable on a mobile phone already exist. However, they would be limited to mobile telephony technology - just an ad hoc solution. Furthermore, such technical problems may be non-trivial in themselves, but they still do not target problems with relevance.

Some efforts are made to capture a receiver context by most metadata standards (albeit limited to technically standardized issues). However, the same cannot be said for the sender context, as experiments in the use of the EASEL system have shown when applied to resources in the field of the Humanities (Borrelli, 2002). Creation of superinformation which must contain rich descriptions of both sender- and receiver-relevant contextual dependencies is a problem which is unlikely to be solved completely or without a great deal of effort. However, a potential path to develop solutions might be found through learning from application of conceptual models, which incorporate contextual creation of approaches to analyse and structure uncertainty.

There are a number of identified issues which are important in drawing a model (see figure below for overview) for a more advanced infrastructure, if we are to avoid some of the possible weaknesses identified in existing systems. Examples include: symmetric and asymmetric dialogue in communication; the ownership and control of user profiles; the roles of different stakeholders; the desire for reusability; and issues of availability and access.
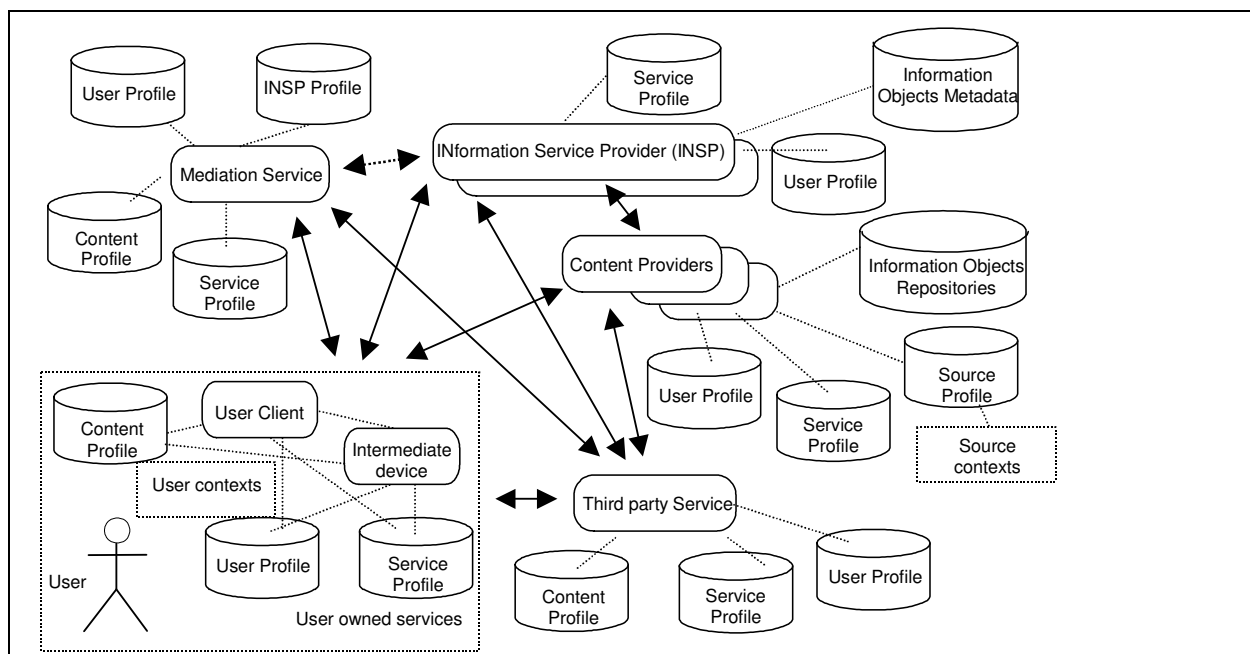

Fig. 4 Some considerations for new infrastructure

We will now draw on these lessons to make recommendations for how development of infrastructure might be supported. Knowledge infrastructure is a complex multidimensional problem space, involving multiple interactions between elements of a serving system and a system to be served. In approaching development of infrastructure there is a need for complex methods of inquiry into the problem space. The difficulty is to explore the perspectives of the various stakeholders individually without loosing an overview of the complexities of the systems involved. Any effort to populate elements within a knowledge infrastructure entails inquiry into uncertainties. To inform developers in relation to multiple participant perspectives an exploration into individuals' sense-making processes is needed. Any analysis into sense-making processes cannot result in complete understanding but may become a steppingstone to a position from which common ground can be reached. While uncertainty can never be resolved, it may be possible through such an enquiry for uncertainty to be structured. An example of a framework for structuring uncertainty with the purpose to populate an initial model of a knowledge infrastructure is the SST framework (see figure below).
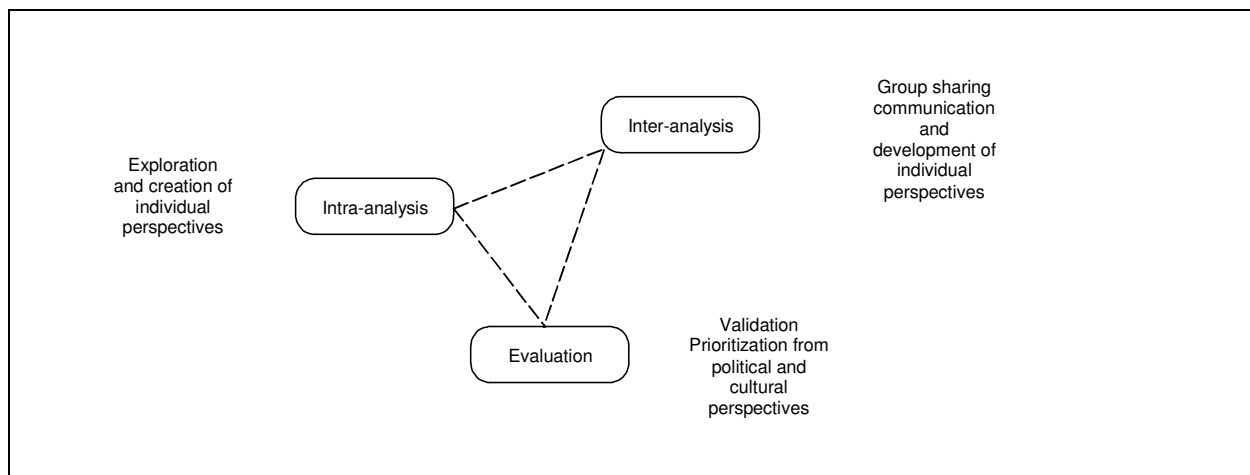

Fig. 5 SST framework overview.

The purpose behind the SST framework is to provide users with a systematic approach for systemic inquiries into a problem space from each participant's point of view (Bednar, 2000). As such it may be used with the involvement of sample users from key stakeholder groups to develop a foundation of knowledge upon which an initial population of key elements can be achieved. Any inquiry into key elements needs to draw upon issues such as the following:

Socio-technical issues

The possibility to locate and access 'relevant' objects is a socio-technical issue and cannot be solved by technology alone. Social relevance could be supported according to descriptions of particular user needs (e.g. interest, experience, goals etc). Regarding technical personalized delivery, the emphasis needs to be on dynamic adaptation and therefore solutions need to be based on vendor-independent and technology-independent protocols. Concentration on any particular

technology in common use today would result in a fall back into the same trap – creation of a static system.

Meta-level standards

Reflecting on communication paradigms leads us to consider the next level of development needed for an infrastructure that includes meta-level standards and protocols. There is a need to rethink standards and protocols which can provide support for access to learning objects which are relevant to user needs. Problems which follow from this are therefore concerned not only with defining learning objects but also with validation of relevance.

Description styles

We note that even for qualified specialists and professionals the use of currently available systems is not always straightforward, efficient or effective. It can be difficult to extract and validate relevant objects from combinations of different systems as each might require a different mindset. Description styles and indexing strategies used in different systems may themselves differ, yet still be correct. Specialist jargon may be used to express information within particular communities of practice and may not be easily understood by outsiders or out of context.

Sense-making

Sense-making activities are subject to perceptual and judgmental bias. Difficulties with evaluation of reliability and trustworthiness may be a barrier to transactions. Thus any particular system may in practice be setup to work well only within a narrow domain of competence and culture (e.g. that associated with a particular community of practice). This in itself may not easily be recognized. It is necessary to emphasize the need to differentiate between user needs and descriptions which could be applied to reinterpret models of user needs.

Symmetrical communication

Issues with the project architectures become visible when relationships between users and providers are compared with models of symmetrical communication. If a service is supposed to be a gateway to support users in their search for learning objects from which users assume a high level of quality then clearly the service can only develop or mediate missing descriptions of contextual dependencies through a two-way symmetrical dialogue with its users.

Multiple user profiles

Another major issue relates to a possible multitude of user profiles which may be owned and controlled by individual users and / or by service providers. Any model needs to take into account possibilities for users to extract information about themselves and / or their access devices in order to populate different profiles for different purposes. There may be alternative stakeholders involved in the process of searching and providing learning objects. A model for infrastructure must allow for interactions between users, content creators and providers, i.e. those who give access to objects and other gateway services and technologies.

Bednar, P M, Welch, C and Graziano, A (2007) 'Learning Objects and their implications on Learning: a case of developing the foundation for a new Knowledge Infrastructure,' Chapter 6 in '*Learning Objects: Applications, Implications & Future Directions*'. Harman, K and Koohang, A, eds., Informing Science Press, NY, pp 157-185, ISBN: 83-922337-8-6. [final draft page no:16/21]

Conclusions

In future, systems will be needed to deal with an ever-increasing volume of available learning objects. In this chapter we have discussed key elements of contextual dependencies which impact on possibilities for identifying those learning objects which are most appropriate to user needs. The implications are relevant to clients, agents, service providers and content providers as well as users themselves. Applications and protocols provide structures which can aid users in their efforts to find, access, analyze and evaluate available learning objects. The constructions, transactions and interactions which occur can be viewed as cognitive techniques and tools used by individuals for particular and contextually dependent purposes. A major concern is then the relevance of a learning object to a particular user context. How do individuals find objects that might be of interest? This question relates not only to issues of access and exchange but is more pertinently about the need to avoid information overload while supporting information richness. Is it possible to enable further development of an infrastructure which supports personalized access to learning objects? We have seen how the experience of a number of European projects could inform efforts to develop future infrastructures.

Further development of future infrastructures need to be seen as attempts to incorporate more fully the idea of contextual dependency. This may assist in the accommodation of communicative requirements from the perspectives of multiple device capability within systems architecture. This may in turn assist in the creation of a dynamic environment for learning object reuse. In addition to technological demands the specific and complex requirements of user sense-making processes also require consideration. A systemic incorporation of life's hidden agenda may help users to focus on evaluation of relevance and appropriateness of objects. However the need for user protection brings in further complication to developments. Users are subject to continual evolution in their sense-making, making inquiry at increasing level of sophistication as continual curiosity spurs on exploration. A modeling process of the framework for metadata is complicated by the dialectic where both architecture and infrastructure for technologies employed, and user requirements for object retrieval are in a constant state of flux.

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Chapter Summary

In an era of lifelong learning, empowerment of the learner becomes fundamental. Therefore exploitation of the full potential of learning objects depends upon creation of an appropriate infrastructure to promote symmetrical control of inquiry. The learner needs to be empowered because learning is a discovery process and thus must be under his or her own control.

In early stages of education it is often assumed that choice of material is to be decided by experts. At the more advanced stages, however, any subject problem space becomes more complex, and thus any decision related to relevance of inquiry properly rests with the learner. However without access to relevant contextual material (in addition to content) the learner will not be in a position to make responsible judgments.

Two problems are to be adduced. First, current attempts to contextualize content, such as those based on the use of metadata etc, have been shown to be insufficient. Secondly, current developments in infrastructure assume that access and control of inquiry rest with the provider and fail to accommodate support of symmetrical dialogue.

Many strategies for the use of Learning Objects assume that a learner wishes to be led through the material and precludes the possibility of an educational experience which promotes critical thinking (such as that inspired by Socratic Method). We would argue that an infrastructure is needed which is capable of supporting both types of learning practice.

It could be argued that thinking cannot be taught and that the only thing we can hope to achieve in education is mentoring and guidance within a problem space. A number of substantial research projects have been conducted in recent years in partnership between a range of significant European industrial actors and academic institutions. We will draw upon the findings of these projects, in conjunction with contemporary research into individual requirements shaping, in order to suggest a model for developing an infrastructure. This model will allow the possibility for symmetrical control of inquiry between learner and provider of learning objects.

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> This paper describes the metadata models developed and used during the project EASEL and GESTALT. One of the main achievements of the GESTALT project has been to show the usefulness of metadata for enabling effective resource discovery services. Although performed on a limited subset of metadata elements, results have been positive and therefore encouraging. The Metadata model developed during GESTALT, called GEMSTONES contributed to the standard IEEE LOM v4.0 (Learning Object Metadata).

F. Borrelli , F. Castaldo , A. Graziano, S. Russo, I. Scarpa, V. Vecchio. (2002). *Experiences with learning objects reuse support tools within the EASEL project*. 2002 Annual EDEN Conference

A. Graziano, S. Russo, I. Scarpa, V. Vecchio (2002). *The EASEL project and the reuse of digital learning objects*. AICA 2002, XL Congresso Annuale, ICT Globalizzazione e localismi, Conversano, Bari

> These two papers refer to the EASEL project, they include descriptions of the architecture and project. The use of the metadata models used in EASEL is covered, in conjunction with the discovery architecture, to allow for the reuse of existing learning material.

A. Graziano, P. Foster, S. Russo, V. Vecchio (2002). *Metadata Models for QoS-Aware Information Systems*. The Fourteenth International Conference on Software Engineering and Knowledge Engineering, Ischia, ITALY,July 15-19, 2002 (ACM).

> This paper refers to the GUARDIANS project and shows how with the help of rich metadata it is possible to use QoS in the delivery of learning objects. The QoS refers not just to the traditional technical and network-based QoS but also to learning objectes that are suited for the end user specific platform and OSs (e.g. PDA or iDTV or desktop pc etc.)

Graziano, A., Russo, S., Vecchio, V. (2003*). A Metadata-Based Distributed Architecture for Personalized Information Access*. Proceedings of the 2003 EDEN Annual Conference, Rhodes

> This paper also refers to GUARDIANS and focus on the use of metadata to obtain personalized learning objects. The personalization is based on matching user profile and preferences with appropriate metadata fields describing the learning object

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> The paper describes RENAISSANCE, as a collaborative project, which has defined requirements and a model for holistic networked learner support. Based on these requirements, a working prototype for a Learning Environment has been developed, and tested with live trails using material from the music and computer networking industry.

Notes:

Partners involved in the RENAISSANCE Project:

Fretwell-Downing Ltd (UK)
Dunelm Services Ltd (UK)
National Centre for Popular Music (UK)
Newark & Sherwood College (UK)
Nexor IRL (UK)

Euristix Ltd (UK)
Sheffield College (UK)
Sheffield Hallam University (UK)
Yorkshire Cable Ltd (UK)
University of Sheffield (UK)

Jazz und Rock Schule (Germany)
University of the Aegean (Greece)
Kyros (Greece)
Northwest Labs Ltd (Irland)
Screenphones Ltd (Irland)

Teltec Ltd (Irland)
The Sound Training Centre of Ireland (Irland)
University of Naples (Italy)

Partners in the GESTALT project:

Fretwell-Downing (UK)
University of Sheffield (UK)
ARPA - University of Naples (Italy)
Waterford Institute of Technology (Irland)
Trinity College Dublin (Irland)

Kyros (Greece)
University of the Aegean (Greece)
British Telecommunications (UK)

Partners in the EASEL project:

The Open University (UK)
University of Bristol   (UK)
Fretwell-Downing Education (UK)
South Bank University (UK)
Trinity College Dublin (Irland)
Institut fur Psychologie, Karl-Franzs-Universitat Graz (Austria)
Interactive Labs S.r.l. (Italy)
ARPA - Universita de Napoli Federico 11 (Italy)
SEMA Group sae (Spain)

Partners in the GUARDIAN project:

Fretwell-Downing Learning (UK)
Universita de Napoli Federico 11 (Italy)
British Telecommunications plc, BtexaCT (UK)
NETTUNO (Italy)
University of the Aegean (Greece)
Waterford Institute of Technology, TSSG (UK)
The Open University, Institute of Educational Technology (UK)

Partners in the MRU network:

Lund University (Sweden)
Universita de Napoli Federico 11 (Italy)
University of Portsmouth (UK)
University of Northumbria (UK)
Sheffield Hallam University (UK)

Bednar, P M, Welch, C and Graziano, A (2007) 'Learning Objects and their implications on Learning: a case of developing the foundation for a new Knowledge Infrastructure,' Chapter 6 in '*Learning Objects: Applications, Implications & Future Directions*'. Harman, K and Koohang, A, eds., Informing Science Press, NY, pp 157-185, ISBN: 83-922337-8-6. [final draft page no:21/21]