e-Learning System Overview based on Semantic Web

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Abstract: The challenge of the semantic web is the provision of distributed information with well-defined meaning, understandable for different parties. e-Learning is efficient task relevant and just-in-time learning grown from the learning requirements of the new dynamically changing, distributed business world. In this paper we design an e-Learning system by using a semantic web and show how the semantic web resource description formats can be utilised for automatic generation of hypertext structures from distributed metadata. It is primarily based on ontology-based descriptions of content, context and structure of the learning materials and thus provides flexible and personalised access to these learning materials.

Keywords: e-Learning, semantic web, ontology, education hypermedia.

1. Introduction

"e-Learning is just-in-time education integrated with high velocity value chains. It is the delivery of individualised, comprehensive, dynamic learning content in real time, aiding the development of communities of knowledge, linking learners and practitioners with experts" Drucker (2005).

E-Learning aims at replacing old-fashioned time/place/content predetermined learning with a just-in-time/artwork-place/customised/on-demand process of learning. It builds on several pillars, viz. management, culture and IT (Maurer and Sapper, 2001). e-Learning needs management support in order to define a vision and plan for learning and to integrate learning into daily work. It requires changes in organisational behaviour establishing a culture of "learn in the morning, do in the afternoon". Thus, an IT platform, which enables efficient implementation of such a learning infrastructure, is also needed. Our focus here lies in IT (Web) technology that enables efficient, just-in-time and relevant learning. Table 1 shows the characteristics of the standard training and the improvements achieved using the e-Learning approach (Maurer and Sapper, 2001). e-Learning has its origins in computer-based training (CBT), which was an attempt to automate education, replace a paid instructor, and develop self-paced learning. But the focus of e-Learning is to extend and improve the users and business' needs (Barker, 2000). Key to success is the ability to reduce the cycle time for learning and to adapt "content, size and style" of learning to the respective user and their business environment.

Technologies have been enhancing education all the time and new technologies have always been utilised firstly by education, especially with the emerging of computer related information technology (Devedzic, 2000). Network education (including distance education, distance learning), or e-Learning with the growth of computer networking. Wireless and mobile computing have resulted in mobile education or m-Learning. With wireless and mobile technologies, it is possible to realise anytime, anywhere, anyway, any device for learning and educating. Implementation of the m-Learning involves adding mobile computing technologies into the old e-Learning system. Modifying old systems needs a lot of work: redesigning architecture and re-implementing the m-Learning system. In the meantime, a large number of universities will update their systems and many more educational resources will be ported to new systems.

Table (1): Differences between training and e-Learning (Maurer and Sapper, 2001)

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Training</th>
<th>e-Learning</th>
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</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>Push – Instructor determines agenda</td>
<td>Pull – Student determines agenda</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Anticipatory – Assumes to know the problem</td>
<td>Reactionary– Responds to problem at hand</td>
</tr>
<tr>
<td>Access</td>
<td>Linear – Has defined progression of knowledge</td>
<td>Non-linear – Allows direct access to knowledge in whatever sequence makes sense to the situation at hand</td>
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<tr>
<td>Symmetry</td>
<td>Asymmetric – Training occurs as a separate activity</td>
<td>Symmetric – Learning occurs as an integrated activity</td>
</tr>
<tr>
<td>Modality</td>
<td>Discrete – Training takes place in dedicated chunks with defined starts and stops</td>
<td>Continuous – Learning runs in the parallel to business tasks and never stops</td>
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</table>
2. e-Learning benefits

“The biggest growth in the internet, and the area that will prove to be one of the biggest agents of change, will be in e-Learning.”

By: John Chambers, CEO, Cisco Systems

Many of the benefits of e-Learning derive directly from the drivers themselves, e.g., global reach consistency of message and ability to learn anytime, anywhere. But e-Learning in the corporate environments offers other benefits as well. First, e-Learning enables companies to update materials and information across the entire enterprise, keeping content fresh and relevant. This is especially important as product-development cycles continue to diminish, product modifications become more frequent, and company organisations and policies become more volatile. Second, online training also creates a personalised learning experience. Instead of daylong or weeklong programmers, the typical e-Learning course can be broken into one-hour modules, offering flexibility around training. Employees can adapt training to their own lives and learning styles, accessing material whenever it is convenient to review course material.

Third, e-Learning is ideal for global corporations with people in multiple time zones, there is no need to coordinate travel and delivery schedules. Global companies, however, do need to address language and localisation issues. Fourth, Internet-based training can reduce costs, with housing and travel costs accounting for the majority of the savings. Lost productivity and revenue from classroom training can actually be higher if one considers time spent away from the office. Finally, there is evidence that e-Learning benefits corporate operation. e-Learning on the whole, appears to offer many improvements, both in the tangible as well as the intangible world. Some of the other benefits can be summarised as shown in Table 2 (Rosenberg, 2001).

Table 2: Benefits of e-Learning

<table>
<thead>
<tr>
<th>Benefits of e-Learning</th>
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<tr>
<td>Information is consistent or customised, depending on need</td>
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<td>Everyone gets the same content, presented in the same way. Yet the programs can also be customised for different learning needs or different groups of people</td>
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<tr>
<td>Content is more timely and dependable</td>
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<tr>
<td>Because it is web-enabled, e-Learning can be updated instantaneously, making the information more accurate and useful for a longer period of time. The ability to upgrade e-Learning content easily and quickly, and then immediately distribute the new information to users is extremely time efficient.</td>
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<tr>
<td>Learning is 24/7</td>
</tr>
<tr>
<td>Students can access e-Learning anywhere and at any time of the day. It’s “just in time – any time” approach makes the learning process ubiquitous.</td>
</tr>
<tr>
<td>Universality</td>
</tr>
<tr>
<td>e-Learning is web-enabled and takes advantage of the universal Internet protocols and browsers. Concern over differences in platforms and operating systems is rapidly fading. Everyone on the Web can receive virtually the same material in virtually the same time.</td>
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<tr>
<td>Scalability</td>
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<tr>
<td>e-Learning solutions are highly scalable. Programs can move 10 participants to 100 or even more participants with little effort or incremental cost (as long as the infrastructure is in place).</td>
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<tr>
<td>Builds communities</td>
</tr>
<tr>
<td>The Web enables students to build enduring communities of practice where they can come together to share knowledge and insight. This can be a tremendous motivator for learning.</td>
</tr>
<tr>
<td>e-Learning lowers costs</td>
</tr>
<tr>
<td>Despite outward appearances, e-Learning is often the most cost effective way to deliver instruction or information. It cuts travel expenses; it can also reduce teaching time, and significantly reduces the need for a classroom/teacher infrastructure.</td>
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</table>
3. Learning theory

e-Learning associated with any learning that incorporated any form of technology. E-Learning used synonymously in dialogue concerning flexible distance learning. However with the recent surge to incorporate more computer technology into classrooms, at all levels.

e-Learning can be defined as all that activity utilising information transfer and knowledge utilisation during the learning process with particular attention to computer-based technology involving learning activities in relation to primary school classroom environment. Research on flexible learning has been driven by what many are calling the "information revolution". Research on Flexible learning is becoming increasingly more visible as a part of the higher education family. But the research and literature reviewed for this study indicate that the higher education community has a lot to learn regarding how and in what ways technology can enhance the teaching/learning process. The recent work on social cognition . . . has shown clearly that information is processed in wondrous ways, few of which are replicate of the original information . . . the gist of this more recent work is roughly that individuals, alone or in organisations, transform and use research in highly selective and strategic ways (Huberman,1987).

The perspectives on knowledge use described by Huberman draw from a learning theory known as constructivism, which has moved to the forefront of educational theory in recent years (Huberman, 1987). A learning environment begins now to look more like a mix between the teaching strategies based in a critical inquiry and the teaching conditions, which are thought to support the goals, which these strategies hope to achieve. While no learning environment is ever complete, therefore the sense of its completion must derive less from a necessity to deliver all that learners need and more from its ability to allow learners to integrate various models of reality in ways that enable their meaningful management (Checkland, 1991).

4. Information technology and knowledge

Knowledge cannot be stored in computers; it can only be stored in the human brain (Davenport and Prusak, 2000; Lytras, et al, 2002), knowledge is what a knower knows; there is no knowledge without someone knowing it. Knowledge is information combined with experience, context, interpretation, reflection, intuition and creativity. Information, which can be stored in computers, becomes knowledge once it is processed in the mind of an individual. This knowledge then becomes information again once it is articulated or communicated to others in the form of text, computer output, spoken words, or written words or other means. Six characteristics of knowledge that distinguish it from information:

1. Knowledge is a human act
2. Knowledge is the residue of thinking
3. Knowledge is created in the present moment
4. Knowledge belongs to communities
5. Knowledge circulates through communities in many ways
6. And new knowledge is created at the boundaries of old.

Knowledge acquisition must be viewed as a cyclic process where old information is taken on board, combined with new information and the user's experiences to create newer updated knowledge. This then in turn reduces the old knowledge to the information level, and the previously utilised information could eventually be even further rescinded - to the data level (Colbeck, 2003). Information technology can play an important role in successful knowledge management initiatives. However, the concept of coding and transmitting knowledge in educational organisations is not new: training and employee development programs, organisational policies, routines, procedures, reports, and manuals have served this function for many years. What is innovative in the knowledge management area is the potential for using modern information technology (e.g. the internet, intranets, extranets, browsers, data warehouses, data filters, software agents, expert systems) to support knowledge creation, sharing and exchange in an organisation and between organisations. Modern information technology can collect, systematise structure, store, combine, distribute and present information of value to knowledge workers (Nahapiet and Ghoshal, 1998).

The successful information technology can be integrated by the following four stages;

1. General Support; the first stage is general IT support for knowledge workers. This includes word processing, spreadsheets, and email. End-user tools are made available to knowledge workers. At the simplest stage, this means a capable networked PC on every desk or in every briefcase, with standardised personal productivity tools (word processing, presentation software) so that documents can be exchanged easily throughout an organisation.

2. Expand Accessible Information Sources; an information system stores information on who knows what in the organisation and outside the organisation. The system does not store what they actually know. A typical example is the company intranet. Information about who
knows what is made available to all people in the organisation and to select outside partners.

3. Advanced Information Sources; the system stores what knowledge workers know in terms of information. A typical example is databases such as Lotus Notes.

4. Expert Systems; information system uses information to simulate expert opinions. A typical example is the expert system: ‘Knowledger’. Artificial intelligence is applied in these systems. For example, neural networks are statistically oriented tools that excel at using data to classify cases into one category or another.

5. e-Learning and semantic web

The great success of the current WWW leads to a new challenge: a huge amount of data is interpretable by humans only; machine support is limited. Berners-Lee suggests enriching the Web by machine-processable information, which supports the user in his tasks. For instance, today’s search engines are already quite powerful, but still return too often too large or inadequate lists of hits. Machine-processable information can point the search engine to the relevant pages and can thus improve both precision and recall. To reach this goal the semantic web will be built up in different levels: Unicode/Unified Resource Identifiers, XML, RDF, ontologies, logic, proof, trust (http://www.w3.org/DesignIssues/Semantic.html).

The important property of the Semantic Web architecture i.e. (common-shared-meaning and machine-processable metadata), enabled by a set of suitable agents, establishes a powerful approach to satisfy the e-Learning requirements. The process is based on semantic querying and navigation through learning materials, enabled by the ontological background. In Semantic Web can be exploited as a very suitable platform for implementing an e-Learning system, because it provides all means for (e-Learning): ontology development, ontology-based annotation of learning materials, their composition in learning courses and (pro) active delivery of the learning materials through e-Learning portals. Table 3 shows the suggested advantages to the possibility of using the Semantic Web for realising the e-Learning requirements.

Table 3: advantages of using Semantic Web as a technology for e-Learning

<table>
<thead>
<tr>
<th>Requirements</th>
<th>eLearning Semantic Web</th>
<th>eLearning Semantic Web</th>
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<tbody>
<tr>
<td>Delivery</td>
<td>Pull – Student determines agenda</td>
<td>Knowledge items (learning materials) are distributed on the web, but they are linked to commonly agreed ontology(s). This enables construction of a user-specific course, by semantic querying for topics of interest.</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Reactionary – Responds to problem at hand</td>
<td>Software agents on the Semantic Web may use a commonly agreed service language, which enables co-ordination between agents and proactive delivery of learning materials in the context of actual problems. The vision is that each user has his own personalised agent that communicates with other agents.</td>
</tr>
<tr>
<td>Access</td>
<td>Non-linear – Allows direct access to knowledge in whatever sequence makes sense to the situation at hand</td>
<td>User can describe the situation at hand (goal of learning, previous knowledge,...) and perform semantic querying for the suitable learning material. The user profile is also accounted for. Access to knowledge can be expanded by semantically defined navigation.</td>
</tr>
<tr>
<td>Symmetry</td>
<td>Symmetric – Learning occurs as an integrated activity</td>
<td>The Semantic Web (semantic intranet) offers the potential to become an integration platform for all business processes in an organisation, including learning activities.</td>
</tr>
<tr>
<td>Modality</td>
<td>Continuous – Learning runs in parallel to business tasks and never stops</td>
<td>Active delivery of information (based on personalised agents) creates a dynamic learning environment that is integrated in the business processes.</td>
</tr>
<tr>
<td>Authority</td>
<td>Distributed – Content comes from the interaction of the participants and the educators</td>
<td>The Semantic Web will be as decentralised as possible. This enables an effective co-operative content management.</td>
</tr>
<tr>
<td>Personalisation</td>
<td>Personalised – Content is determined by the individual user’s needs and aims to satisfy the needs of every user</td>
<td>A user (using its personalised agent) searches for learning material customised for her/his needs. The ontology is the link between user needs and characteristics of the learning material.</td>
</tr>
<tr>
<td>Adaptively</td>
<td>Dynamic – Content changes constantly through user input, experiences, new practices, business rules and heuristics</td>
<td>The Semantic Web enables the use of distributed knowledge provided in various forms, enabled by semantically annotation of content. Distributed nature of the Semantic Web enables continuous improvement of learning materials.</td>
</tr>
</tbody>
</table>
Ontology

An interesting clarification of the philosophical term ontology is provided by Guarino and Gitareta (1995). They summarised several common definitions of ontology as a specification of a conceptualisation, as depicted in figure 1.

Figure 1: A basic classification of ontology
- An informal conceptual system
- A formal semantic account
- A specification of a “conceptualisation”
- As a representation of a conceptual system via a logical theory
  - Characterised by specific formal properties
  - Characterised only by its specific purposes
- As the vocabulary used by a logic theory
- As a (meta-level) specification of a logical theory

The ontology is to formally describe shared meaning of the used vocabulary (set of symbols) (Stojanovic, 2004; Noy and Klein, 2003). In fact, ontology constrains the set of possible mapping between symbols and their meanings. But the shared understanding problem in e-Learning occurs on several orthogonal levels, which describe several aspects of document usage, as sketched in figure 2. From the student point of view the most important criterions for searching learning materials are: what the learning material is about (content) and in which form this topic is presented (context). However, while learning material does not appear in isolation, another dimension (structure) is needed to encompass a set of learning materials in a learning course. The shared-understanding problem in e-Learning occurs when one tries to define the content of a learning document in the process of providing learning materials as well as in the process of accessing to (searching for) particular learning material.

Figure 2 Metadata for describing the content of learning materials
Ontology as an informal conceptual system, figure 3 in the context of e-Learning means that we admit the presence of an (unspecified) conceptual system, which we may assume to underlie a particular knowledge base.

Figure 3: Ontology as an informal conceptual system
This is the common hypothesis in e-Learning implementations. An ontology as a formal semantic account, see figure 4, means that we analysed the phenomenon of e-Learning and we have concluded several semantic that formulate a value layer capable of exploiting knowledge sources semantically. The major problem concerning this interpretation of ontology is the complexity of e-Learning.
6. Metadata

Metadata is structured information system describing resources, created to help in the task of discovering, managing and using them without the need to be read, viewed or explored in some way. Metadata is the total sum of what one can say about any information object at any level of aggregation, considering that an information object is anything that can be addressed and manipulated by a human or a system as a discrete entity (Gilliland-Swetland, 2005). Metadata enable effective search of resources across multiple repositories, since dealing with descriptive surrogates of resources is easier than dealing with the resources themselves. The use of a certain object by different communities can be facilitated by the existence of different metadata records describing it according to metadata schemes tailored to the needs of each community.

The e-Learning Hypermedia System envisaged to achieve adaptability needs to have not only the Hypermedia repository, also called Hyperspace, containing the HTML and XML, pages of e-Learning content, but also a repository containing knowledge about the domain to be taught, i.e., the Knowledge Space composed of the description of each elementary subject that conforms the knowledge space to be covered by the e-Learning content. The Content Knowledge Ontology is a structure of knowledge concerning the actual pieces of e-Learning content, capable of providing composition rules represented in a principled way to enable the configuration of complex learning objects tailored to the student's structure is based on standard metadata to enable interoperability and is encoded in a formal Web ontology capable of supporting reasoning services. The system must have a Student Model representing the knowledge concerning the profile of each individual learner which will be used at run time to decide which goals and preferences must be covered by the e-Learning content that the system provides to the learner. Such a student profile is also object to changes over time because of the student's activities. The student model was modelled and implemented as application ontology.

7. e-Learning system implementation

Figure 5 shows the block diagram of the e-Learning system implemented. Circles indicate activities while rectangles indicate obtained results. Arrows indicate the input or output results of activities. The Conceptual Model containing both the Student Model and the Knowledge Space Model was designed. Based on the Student Conceptual Model, the Student Ontology was designed in order to maintain a machine understandable repository with the student's profile. Based on both the Knowledge Space Conceptual Model and the Metadata Standard Specification, a Metadata Application Profile was designed intended to address the metadata needs for the e-Learning context of the particular project. Based on the identified Adaptability Requirements, the Content Knowledge Ontology was created to maintain the knowledge of each piece of the e-Learning content of the system. Also, the Domain Ontology was created based on the defined application profile and the scope and structure of the domain to be taught. Lastly, the process that automatically generates metadata instances describing the hypermedia repository elements in terms of the Knowledge Space Model was implemented and a procedure to augment the system's metadata by edition was also proposed and used.

8. Conclusion

Making content machine-understandable is a popular paraphrase of the fundamental prerequisite for the semantic web. In this paper we have presented an e-Learning system that exploits it in three ways, for describing the semantic (content) of the learning materials (this is the domain dependent ontology), for defining the learning context of the learning material and for structuring the learning materials in the courses.
The three dimensional, semantically structured spaces enable easier and more comfortable search and navigation through the learning material. Semantic Web is the backbone for e-Learning; a Semantic Web-based learning process could be a relevant (problem-dependent), a personalised (user customised) and an active (context-sensitive) process. These are prerequisites for realising efficient learning.

Figure 5: block diagram of the e-Learning system
References


Establishing Effective e-Learning Communities within the Teaching Profession: Comparing Two Projects to Discover the Necessary Ingredients.

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Abstract: This article sets out to compare and contrast two different projects, aimed to get primary teachers collaborating online, with respect to advice from research on how to engage participants. The first project tried to encourage teachers in small rural schools to share ideas for the implementation of the National Numeracy Strategy. The second was intended to provide a platform for teachers to develop materials for the teaching of religious education in the classroom. There appears to be four ‘necessary ingredients’ for the successful establishment of e-learning communities within practising teachers. These include: face-to-face meetings; high quality IT support; outcomes, which are of real benefit to participants; adequate funding. The outcome of the comparison is felt to add to the knowledge of how to encourage participation in online forums within a context outside those normally researched. As such it should help those trying to design similar projects in the future.

Keywords: Online collaboration, online forums, face to face meetings, project ownership, Religious Education, National Numeracy Strategy, mixed age classes

1. Introduction

Online collaboration between schoolteachers has the potential to improve practice by providing peer support, facilitating the sharing of expertise and reducing the planning workload of those involved. A number of governmental, local education authority (LEA) and commercial websites are available which provide resources for hard pressed teachers to access. However, whilst extremely useful, these do not always provide materials which are tailor-made for particular contexts. Two projects, which set out to encourage online collaboration between primary teachers in the north of England, aimed to do just that. The first focused on the sharing of ideas to enable teachers in small rural primary schools to better cater for the wide range of needs within their mixed age classes during the daily mathematics lessons prescribed by the National Numeracy Strategy (NNS), a teaching framework introduced in 1999 which advocated the increased use of whole class teaching and differentiation of work at three levels. The second project brought together a group of primary teachers, who were subject co-ordinators for religious education (RE) within their schools, with the aim of preparing teaching materials, which could be used by themselves and others. In both projects the intention was for communication to be through the medium of online discussion boards, yet the outcomes were very different.

This paper outlines the research that was carried out to investigate the outcomes of these two projects in order to find out what conditions are needed to encourage teachers to participate in online collaboration. Much time and effort was invested in both projects with very different results and it was felt that if the reasons for the differing levels of success could be uncovered, and a list of ‘dos’ and ‘don’ts’ be built up, then this would provide useful advice to those who might be considering embarking on similar ventures in the future. Consequently the question that needed addressing by the researchers was: What are the necessary steps that need to be taken to encourage online collaboration between busy primary teachers?

The paper first discusses some of the general issues that need to be taken into consideration when setting up systems for online collaboration within the teaching profession. It then outlines the methodology of the research undertaken before moving on to comparing and contrasting the outcomes of the two projects and discussing the possible reasons for any differences. The paper concludes by making some suggestions to facilitate successful outcomes of such projects in the future.

2. Encouraging online collaboration between practising teachers

Much research (McConnell 2000; Annison, J. 2002; Vrasidas and McIsaac1999) has been carried out on the levels of participation of students in online discussion boards as part of
their further or higher education courses. Although such research can provide us with some useful information it may not be possible to directly transfer this to such a different context as practising teachers. The majority of students engage in courses in order to gain further qualifications and, if online collaboration is a requirement, there is some incentive to participate. Although recent advice (DfES 2003:78) encourages teachers to collaborate, sharing ideas and jointly preparing materials with colleagues from other schools is not a requirement. They could carry out their job without the added complication of having to collaborate. In the experience of the researchers few teachers seem to implement a collaborative approach. Where there is collaboration this tends to be within, and not across, schools. In this section only the advice from research, which seems most pertinent to the setting up of an e-learning community of full time practising teachers will be discussed.

There are a number of studies providing reasons for people meant to be engaging in online forums not wanting to become involved. Clouder and Deepwell (2004) found that many in their study of student participation in online forums were hesitant in starting off a discussion for fear of being thought to be too keen, and Latch and Zimring reported ‘evaluation apprehension’ arising from students thinking ‘…that others in the group know more than they do or that the group is being judged’ (2000:4). Wegerif argues that failures in online courses develop where students are not able to ‘cross the threshold from feeling like outsiders to feeling like insiders’ (1998:34). Cramphorn suggests that to overcome this sort of problem the instructor must develop an environment that is ‘democratic, respectful, open to challenges, prepared to give grounds for statements and seeking critically grounded consensus’ (2004:48). The sending in of encouraging ‘seed’ messages to get the forums started could be one way of ensuring participants do not feel that they look pushy or are having to break the ice, something advocated by Tenby (2003). Salmon (2000) listed training participants in the use of the technologies that were to be used as being of particular importance and, later (2002), that the purposes and benefits of the tasks to be carried out online should be made clear in order to motivate participants to carry them out. This would appear to be sound advice for anyone intent upon organizing an online learning community. Likewise Insung Jung et al (2002), The Open University (2002) and Moore and Kearsley (1996) all highlighted the importance of providing feedback to participants in online forums in order to motivate them, the OU suggesting that there should at least be a response to all first postings (2002:112). Vonderwell (2003) reported negative student feedback in a project where the moderator was not consistent in timing when responding to postings. It appears then that speedy feedback is important.

Tolmie and Boyle (2000:122-3) list a number of factors associated with successful computer mediated communication (CMC), which appear directly relevant to the projects under discussion. The first of these is the need to keep the size of the participating group small to allow for a more balanced use of a forum. This advice was followed by the instructor in Vonderwell’s study in order to ‘prevent information overload and to ensure that students read each other’s responses and engaged in interaction’ (2003:80). Tolmie and Boyle also advocate participants knowing each other, something that Vonderwell agrees with having found that some of the students in her study were reluctant to get involved, seemingly ‘uncomfortable about interacting with the students who they did not know beforehand’ (2003:82). Tolmie and Boyle (2000) also suggest that participants in online forums need to have had some experience in CMC in order for the venture to be successful. This would appear to be a ‘catch 22’ situation unless ‘experience in CMC’ can mean as little as being able to use email. Their suggestions for participants to have ownership of the task and an understanding that there is a clear need for the communication to be computer mediated appear to be far more straightforward. The two projects under review appeared to follow some of the above advice with varying degrees of success. The following section outlines the methodology used to compare the two in order to ascertain what the necessary ingredients for successful online collaboration between practising teachers might be.

3. Methodology

The first step in answering the research question set was for the researchers to look at each of the projects in turn and understand the different contexts. Next those pieces of advice discussed above which each of the projects appeared to follow were listed to allow a comparison to be made. In order to judge whether or not the projects were successful a set of criteria were devised and applied to each project in turn. It was decided that two possible measures of success would be the number of teachers agreeing to participate and the number of postings they sent into the discussion boards; whilst recognising that quantity does not necessarily mean quality this would provide a simple way of judging the degree to which online communication took place. A third
measure of success was identified as being the number of prompts needed from the project leaders to maintain the impetus of the projects; the fewer the prompts the more motivated the participants were likely to be. Finally the end results needed to be looked at to find out exactly what the projects achieved. The production of teaching resources, which could be utilised by others, would be seen as a successful outcome. So too would online interactions which showed that an idea from one individual was being utilised in some way to improve practice by another. Ideally both projects would have been fully evaluated by the participants themselves and the results of these evaluations would have provided a rich source of data. Whilst this was done with one of the projects, due to the lack of participation within the other it was not possible to carry out such an evaluation. The results of the comparison of the two projects will now be outlined and analysed within the next section of the paper.

4. Results

4.1 Overviews of each project

4.1.1 Project 1 - The 'mathematics in small schools' project

This project was an extension of a previous investigation into the implementation of the NNS in small rural schools. Two questions raised in the original study (Evans 2001:73) as being of particular significance in such a context were:

a) How can very young reception children in a mixed age Foundation Stage / Key Stage 1 (F/KS1 or 4-7) class be given an appropriate mathematical experience?

b) How can particularly able mathematicians be appropriately challenged in whole KS classes if teachers follow NNS guidance that advocates differentiation at only three levels?

The project involved setting up a web-based discussion board, for invited colleagues in small schools within an Initial Teacher Training (ITT) provider/schools partnership, to share and discuss strategies used to deal with these two groups of children. The aim was two-fold. In particular the hope was that the discussions would provide planning advice for students working within such contexts during their school experience placements. However, it was also the intention that by engaging in this type of discussion the teachers would be able to improve their own practice when implementing NNS style daily mathematics lessons in the context of a mixed age class. The project leader set up the discussion board in November 2001 on the JISCmail site and sent out a circular to all 100 small schools within the partnership informing them of the newly set-up forum and inviting them to join and send in a response to the initial discussion prompts within the circular.

4.1.2 Project 2 - The 'Culham Trust' project

This project was set up to allow an RE adviser and an Information Technology (IT) consultant to work with a group of primary school RE co-ordinators to develop learning materials for the primary age phase in which ICT was an integral and authentic part of the learning process. This type of initiative, according to Sutherland (2005) will help teachers ‘...start to embed ICT into classroom practices’ something that, according to OfSTED (2004) is still needed across the curriculum. Most of the communication between participants was done through the medium of an online php discussion board.

The project ran over the academic year 2004-05 and consisted of three phases. During the first of these (autumn term 2004) the project team was established – the group included representatives from a range of dioceses, LEAs and schools. The emphasis in phase one was on planning and development, consideration being given to the feasibility of identifying existing appropriate units of work either from LEA/Diocesan syllabuses or Qualification and Curriculum Authority (QCA) guidelines or the developing National Framework for RE and the enhancement of these through ICT and /or the creation of new units of work with an integrated ICT element. An initial face-to-face (F2F) meeting allowed for planning and training in the use of an online php discussion board. Further planning was facilitated through the discussion board hosted by the online RE centre of a local ITT provider. During phase two (spring term 2005) materials developed in phase 1 were trialed by members of the project group within their own school contexts. On line professional exchange/discussion and evaluation continued on the discussion board. The group also met on 2 occasions for F2F discussion and ongoing evaluation. Phase three (summer term 2005) involved reflection on their experiences and revision of the materials produced.

4.2 Comparing the projects against the advice from research and the success criteria

In order to make the comparison of the two projects easier, the advice arising from research has been tabulated in table 1 below.
Table 1: Advice from research followed when setting up the projects.

<table>
<thead>
<tr>
<th>Advice from research followed:</th>
<th>Project 1 Mathematics in small schools project</th>
<th>Project 2 Culham Trust Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send in ‘seed’ messages to encourage participation.</td>
<td>This was done.</td>
<td>This was done.</td>
</tr>
<tr>
<td>Provide training in the IT systems to be used.</td>
<td>Provision of very basic, paper based, training in the use of the JISCmail system in the form of an explanatory leaflet sent to schools invited to participate.</td>
<td>Provision of hands on, F2F training in the use of the php discussion boards at the very start of the project (and continued online support from the ICT project leader throughout).</td>
</tr>
<tr>
<td>Make the purposes and benefits of the project clear.</td>
<td>Done within a letter sent out to invite teachers from selected schools to participate.</td>
<td>Done within a letter inviting teachers from selected schools to participate and during the initial F2F meeting.</td>
</tr>
<tr>
<td>Moderator should respond quickly to all messages posted.</td>
<td>This was done.</td>
<td>This was done.</td>
</tr>
<tr>
<td>Keep the group small to ensure that participants get to know each other.</td>
<td>Invitation to participate was sent to 100 schools in the North Yorkshire area.</td>
<td>Group size limited to 11 school RE co-ordinators plus two project leaders.</td>
</tr>
<tr>
<td>Participants should know each other.</td>
<td>This was not possible.</td>
<td>Available funding used to arrange four F2F meetings throughout the project at mutually convenient venues ensured all participants knew each other and the two project co-ordinators.</td>
</tr>
<tr>
<td>Participants should be experienced in CMC.</td>
<td>This could not be guaranteed. The teachers needed to be working in small rural schools within the college partnership. To insist on this requirement may well have limited the number of participants in the project.</td>
<td>This could only be followed with the five group members involved in the earlier project. It could not be guaranteed in the new group members.</td>
</tr>
<tr>
<td>Participants should have ownership of the task.</td>
<td>This was not feasible, as the project had been specifically set up to answer a pedagogical research question for the benefit of the students within the institution running the project.</td>
<td>It was the participants themselves who decided, during the initial planning period, on what the focus for the collaborative work should be.</td>
</tr>
<tr>
<td>There should be a clear need for CMC.</td>
<td>This was the case - teachers involved would not otherwise meet unless they belonged to the same LEA ‘cluster’ of schools. No funding was available to bring the participants in to a central location for a F2F meeting.</td>
<td>This was the case - teachers involved would not otherwise meet. Limited funding was available to bring the participants in to a central location for face-to-face meetings. The project itself was funded as part of a scheme to improve teachers’ ICT skills so there was an additional need for CMC.</td>
</tr>
</tbody>
</table>

Table 2: Comparison of the two projects against the success criteria

<table>
<thead>
<tr>
<th>Success criteria</th>
<th>Project 1 Mathematics in small schools project</th>
<th>Project 2 Culham Trust Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of active participants</td>
<td>The response to the initial invitation to participate was poor, with only 3 colleagues asking to join the forum by the end of January 2002. A second mail-shot was sent out to the same schools in February 2002 in an attempt to boost both the membership and discussion participation. This had limited success – a further 2 colleagues requested to join the list giving a total of 5 in all.</td>
<td>All of the teachers contacted by the project leaders agreed to participate. These consisted of a core group of five RE subject leaders from a previous project and six new members giving an overall group size of 11 excluding the two project leaders.</td>
</tr>
<tr>
<td>Number of postings</td>
<td>Those that did agree to participate engaged minimally. None sent in any response to the initial discussion suggestions within the welcome message. A second prompt eventually initiated posting of two messages by two participants. It is important to note that both messages were sent directly to the moderator not to the board which meant that</td>
<td>530 postings were made about 119 topics by all involved. About one third of these were from moderators but this left a sizable number of messages posted by participants, seven of who were particularly prolific posting well over 20 messages each (one or two over three times that many). The other participants took a lesser part, posting fewer than 10 messages.</td>
</tr>
</tbody>
</table>
Success criteria & Project 1 Mathematics in small schools project & Project 2 Culham Trust Project

<table>
<thead>
<tr>
<th>Success criteria</th>
<th>Project 1 Mathematics in small schools project</th>
<th>Project 2 Culham Trust Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of prompts needed</td>
<td>An initial prompt was sent to the original members of the list asking them for some thoughts on the discussion issues at the time of the second mail shot (February 2002). Two weeks later a second prompt had to be sent out as there was still no activity on the forum.</td>
<td>The discussions maintained their own momentum with very few gentle reminders from moderators.</td>
</tr>
</tbody>
</table>
| End result | The outcome of the project was a very limited number of single postings briefly outlining how the teachers involved ran their daily mathematics lessons. There was no further interaction after the moderator answered each post. | During the first two phases there was evidence of some innovative practice and a developing ability, on the part of participants, to engage in increasingly analytical and reflective self-evaluation, using the discussion board to promote professional interchange and enhance professional development.
Postings (and the end of project evaluation) evidenced an increasing confidence in planning work in RE with ICT as an integral part of the planning process. Teachers were able to provide training support for each other in the use of power point, interactive white boards and digital photography.
Learning materials were then launched as web based materials through an ITT provider’s RE centre web site and, where possible, linked to other appropriate sites.
See also the outcomes of the evaluation process listed separately below. |

Some additional information is available from the outcomes of the evaluation of project two by participants where a questionnaire of open questions was distributed during the final F2F evaluation meeting (see appendix 1). Eight of the eleven participants were able to attend and complete the form. Responses to the questions often highlighted the benefits of using the discussion board and show just how useful this type of project can be when it is planned and implemented well. Comments, which exemplify this, included views such as:
- Liasing with other teachers using the forum was very beneficial (3*).
- It allowed me to share resources (1), work with colleagues who share a passion for RE (1), are more knowledgeable (1) and were able to increase awareness of RE websites (1).
- Dialogue and interaction with other participants and the project leaders was helpful and encouraging (5).
- Reading others’ lesson evaluations on the forum allowed me to amend my own plans (2).
- Being accountable to other colleagues made me persevere (1).
* Numbers in brackets indicate the numbers of respondents voicing this opinion.

5. Analysis of the results

With regard to following advice from research figure 1 shows that the two projects had some common ground. However, in spite of this the outcomes, listed in figure 2, were very different and by looking at the differences, rather than the similarities lessons can be learned. There were three main areas where the two projects differed a good deal; these were to do with the inclusion of F2F sessions, the provision of IT support and establishing ownership of the project. Each of these will now be looked at in turn.

5.1 Inclusion of F2F sessions

It appears that the introduction of some F2F sessions may well have had the big impact on the success of the ‘Culham Trust’ project. Through these the participants were able to meet the two project leaders and get to know them on a personal level. Both were the kinds of people who were very likeable, would instil confidence and motivate participants to become involved. Because of this any ‘seed messages’ were being sown to good effect, unlike the ‘Maths in Small Schools’ project where the project leader was unknown to the teachers and, therefore, likely to be of little importance to those being invited to participate. Here the ‘seed’ messages were of little use in encouraging participation. Likewise any responses to postings by the moderator did
little to encourage further debate, unlike similar responses within the ‘Culham Trust’ project. The teachers involved in the ‘Culham Trust’ project enjoyed their days out of school, meeting colleagues and getting to know the project leaders well. This gave them motivation to make sure that the project succeeded, as they did not want to let their colleagues down. The postings on the forum tended to be very friendly and it was apparent that the participants were enjoying the experience. The two messages to the ‘Maths in Small Schools’ forum tended to be far more formal and definite ‘one offs’. There was no cause for them to be otherwise; although the number of eventual participants was half that of the ‘Culham Trust’ project there was no way that the teachers could get to know who else was involved and this could well have affected their level of participation. This echoes Vonderwell’s findings (2003) mentioned earlier.

5.2 Provision of IT support

The F2F training session which allowed participants to register for and find out how to use the discussion board contributed to the success of the ‘Culham Trust’ project as only one reported having difficulties with this. The session also allowed the original project members to share their expertise and personal experiences of online communication much more meaningfully with newer participants. Once participants were aware of who they could ask when they ran into problems a mutual support system developed naturally. This type of mutual support was not available in the ‘Maths in Small Schools’ project as the participants did not know each other at all. The paper-based information leaflets, although simple and explicit, did not appear to be sufficient to help teachers overcome their difficulties in the ‘Maths in Small Schools’ project as evidenced in their emailing the postings directly to the moderator. According to OfSTED (2004) the training provided for teachers by the Government funded programme in recent years (New Opportunities Fund training in the use of ICT for teaching and learning) has been variable and it could well be that those invited to participate in the ‘Maths in Small Schools’ project were lacking in ICT skills. Although paper based information leaflets are useful as ‘aide memoirs’ once someone is conversant with a system, they are not sufficient to provide the support needed to get started.

5.3 Establishing ownership of the project

This was the second area where the two projects differed completely. In the ‘Culham Trust’ project it was the participants themselves who decided what the project should involve. This was a deliberate decision by the project leaders as not having a sense of ownership of the task was something that had caused the initial ‘Culham Trust’ project to be less than successful. Previously the project leaders had imposed materials. The reason for this was that project leaders had identified reluctance within undergraduate students to criticise the work of peers online, something also found by Light and Light (1999 cited in Williams (2000)). They thought that if the participants were given material to critique then they would be more likely to do so as they were not commenting on their colleagues’ ideas. However, evaluation of the first project had shown them that, unlike students, the teachers would have preferred to have had ownership of the materials, and would have been willing to be constructively critical so, for this second project the leaders made sure that this was the case. Task ownership within the ‘Culham Trust’ project meant that all participants ended the project with a set of useful resources, relevant and specific to their context, which could be utilised in future years. In the ‘Maths in Small Schools’ project this was not the case. The project leader decided on the purpose of the discussions i.e. to be able to gather advice for students on placement and the few short messages that were posted were unlikely to have added much to the knowledge of maths planning of the participants. The benefits to the teachers were few – namely that the students who might eventually arrive in their particular classrooms would be better prepared for their teaching placements. This was rather too long term and not necessarily seen as important, after all some on the spot advice could be given as it was needed.

In addition to the above, the ‘Culham Trust’ project participants were working to a tight timescale in order to produce the materials in time for a particular religious festival and were taking part in something, which was immediately relevant, as it would help them in their planning. In the ‘Maths in Small Schools’ project, although the aim of the project was made clear and the advantages of having better informed students on placements in the schools highlighted, there were no deadlines and participation was probably seen as a nuisance – something over and above what would normally have to be done.

6. Conclusion

Whilst much of the advice given by previous research has been followed in both of the projects discussed it would appear that there are some ‘necessary ingredients’ for the successful establishment of online learning communities.
The real key to success appears in F2F meetings, which allow the participants to get to know each other on a personal level. Whilst other online communities within the teaching profession (the Times Educational Supplement forums being a prime example) may well function successfully without this it has certainly helped in the ‘Culham Trust’ project. The group gelled from the start and felt a sense of obligation to each other and to the project leaders. These meetings also allowed a good level of initial ‘hands on’ training to be given from which the benefits were reaped throughout the project. The provision of high quality support in the areas being developed would also seem to be an important issue. In the ‘Culham Trust’ project the two project leaders were accessible experts in RE and ICT and were able to give a great deal of advice. More experienced colleagues within the group were also able to provide support. In the ‘Maths in Small Schools’ project the leader was not an expert in the implementation of the NNS in small rural schools. This was made clear in the initial letter. The aim was simply to facilitate communication on the participants’ and students’ behalf.

Ensuring that the project arises from the participants themselves and is of real practical benefit to them is a third important aspect. The ‘Culham Trust’ project not only aimed to help participants in their normal RE planning process but also to improve their ICT skills. It was clearly worth getting involved. In contrast, the ‘Maths in Small Schools’ project was less enticing as it was not providing any immediate benefits to participants. The first two of these ‘ingredients’ do not come cheap so a reasonably substantial budget could also be said to be necessary. Access to funding to pay for meeting venues, lunches, travel costs, supply cover, administration costs and the time of the project leaders enabled the ‘Culham Trust’ project to gain the benefits of F2F meetings, the ‘Maths in Small Schools’ project only had sufficient funding to cover administration costs and time out of teaching for the project leader so was at a disadvantage from the start. It is hoped that the sharing of the outcomes of these projects can add to the body of knowledge other prospective e-learning community project leaders can draw on when designing online communication systems. Having enthusiasm for the project is important but if full-time practising teachers are to be encouraged to participate then good design and financial support is vital if the venture is to succeed within a profession where time is a precious commodity.

7. Acknowledgements

The authors would like to acknowledge the teachers involved in the ‘Culham Trust’ project for agreeing to give up time to participate in this venture and the Culham Trustees for their funding support. They would also like to give special thanks to the late Dave Evans whose understanding of technology and how people collaborate online ensured the success of the ‘Culham Trust’ project.

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Appendix 1
The ‘Culham Trust’ Project Evaluation Questionnaire
a) From the point of view of RE, what did you do during the course of the project that you wouldn’t have done had you not been involved?
b) What parts were successful and which were not?
c) From the point of view of ICT what did you do during the course of the project that you wouldn’t have done had you not been involved?
d) What parts were successful and which were not?
e) What have you done since the Easter period as a result of being involved in the project?
f) What plans do you have for the future arising out of your involvement in the project?
g) Is your confidence in RE teaching diminished/ the same / increased as a result of being involved? In what ways?
h) Is your confidence in your use of ICT diminished/ the same / increased as a result of being involved? In what ways?
The Importance of Online Community in Student Academic Performance

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Abstract: This study sought to investigate four separate issues regarding student performance in a blended learning environment in the delivery of a Psychology course to 140 University undergraduates. Firstly, to investigate the relationship between student performance on three different coursework assignments and their performance on interim online assessments. Secondly, to investigate the relationship between student performance on coursework assignments and their perceptions of online community. Thirdly, to investigate the relationship between students’ online community scores and their engagement with an online assessment. Finally, to look at the relationship between students’ cognitive information processing style and coursework performance. The findings revealed that student coursework performance was positively related to their engagement with the online assessments. Furthermore, student online community scores were related to their coursework performance as was cognitive style. The results are discussed in terms of a consideration of these three factors in course design within a blended learning framework.

Keywords: Community, cognitive style, interim assessment

1. Introduction

The initial rationale underpinning the use of an interim online assessment system is to monitor and identify, early on in a course, those students who appear to not understand the course material. The most expedient way to achieve this is through the use of online multiple-choice tests (MCQs). Students obtaining low scores here can then be offered additional help and instruction. Furthermore, such a system could also be useful as a way of identifying students who are failing to attend classes, or students who are attending classes less regularly than other students.

One further possible reason for student success or failure on a particular course is the degree to which these students engage with that course and with the other students on the course. This sense of engagement between learners is referred to as sense of classroom community. Rovai (2002) offers an explanation of sense of classroom community as being mutual interdependence and a sense of trust and interaction among community members. This means that the members of the community have shared goals and values. Online community needs to be thought of in terms of the activities people perform together in their group and not physically where they perform such activities. There are four components of classroom community outlined by Rovai (2001) and these are described as follows. Firstly, ‘spirit’ which is the feeling of belonging to and acceptance of a group identity. This refers to the recognition of membership of a community and the feelings of cohesion that develop amongst learners in a group as a result of this. Secondly, ‘trust’ is simply the feeling that the group can be trusted and the group members will give feedback to each other. Once this is established, members of the group or community can speak with confidence to other members of the group. Thirdly, ‘interaction’ is the feeling that community members have that they may benefit by interacting with other members of the community. Finally, ‘learning’ is the sense that community members have that learning can come about due to the community discussing information, that is, the community can construct knowledge. In a typical online environment group members may engage in interactive behaviour such as discussion, exchange of ideas and seeking advice.

1.1 Community

There is a body of evidence that would argue in favour of the importance of a sense of community in learning. For example, Wang (2001) argues that community can also result from shared knowledge among learners in an online environment, and the evidence suggests that interaction between learners in online courses could be of great importance to learner success (e.g. Shale and Garrison, 1990). Indeed, Citera (1998), suggests that online discussions encourage more reticent individuals to participate to a greater extent, while Warschauer (1997) advocates interaction in online environments, where there is less opportunity for intimidation between individuals and, in asynchronous settings, less time pressure than in face-to-face interactions. However, the lack of a sense of close interaction between learners in an online environment may have adverse consequences, which may be because learners experience feelings of isolation. Haythornthwaite, Kazmer, Robbins and Shoemaker (2000), suggested that...
the participants in their study who failed to make online connections with other learners in their group reported feeling isolated and more stressed than those who made more connections. It would seem therefore that a strong sense of community and interaction is also crucial in online learning environments.

1.2 Individual differences
Although the studies cited above indicate the extent to which sense of community is necessary for effective learning in both face-to-face and online environments, it is pertinent to recognise that individual difference factors have also been shown to have an effect on sense of classroom community. For example, Rovai (2002) has demonstrated that there are differences in sense of classroom community between males and females, with females reporting a greater sense of community, and Kim and Bonk (2002) have demonstrated differences in sense of community cross-culturally, with students from the USA displaying a greater sense of community than those from Finland. Recently, Graff (2003) has provided some evidence to suggest that sense of classroom community is related to an individual’s learning style, with those possessing a globally orientated, socially dependent learning style reporting a lower sense of community than those possessing an analytic less socially dependent style. Accordingly, it is also possible that the way in which a student learns, may be identified by an assessment of individual difference factors, and one of the most profitable areas in this case is the notion of cognitive style.

1.3 Research questions
Four specific research questions were tested here. Firstly, what is the relationship between performance on coursework assignments and performance on interim online assessment? Secondly, is there a relationship between performance on assignments and classroom community scores? Thirdly, what is the relationship between classroom community scores and MCQ engagement? Finally, what is the relationship between cognitive style and coursework performance?

2. Method
2.1 Participants
Participants in this study were 140 first year undergraduate students. These were 25 males and 115 females ranging in age from 18 to 54 with a mean of 23.15 and an SD of 8.11.

2.2 Assessment methods
2.2.1 Online multiple choice questions
After each lecture, students were required to attempt several online multiple-choice questions based on the content of the lecture. The questions were posted on Blackboard, an example of which is shown in Figure 1 below. Correct responses to Blackboard questions yielded a normal distribution.

![Figure 1: Example multiple-choice questions](image-url)
2.2.2 Coursework assignments

Three different types of assessment were utilised in this course. These were:
1. A short essay 800 words.
2. A critical evaluation of a psychology article. For this, students had to choose an article and write about the psychological implications of the article's content from their knowledge of psychology. This was not meant to be an essay, but merely a commentary.
3. A long essay 1500 words.

2.3 Psychometric instruments

2.3.1 Cognitive styles index (Allinson and Hayes 1996)

The Cognitive Styles Index (CSI) (Allinson and Hayes 1996) is a self-report test designed to measure the analyst-intuitive dimension of cognitive style. The term intuitive is used to describe an individual who makes judgements based on feelings and who adopts a global approach to processing information, whereas the term analytic describes an individual who makes judgements based on reason, and who focuses on specific detail when processing information. Analysts tend to be inward looking and self-reliant, whereas intuitives are more socially directed orientation and look more to others. The CSI contains 38 statements, to each of which a respondent must indicate a true/uncertain/false response. It has a theoretical maximum score of 76. Higher scores indicate a more analytical cognitive style and lower scores indicate a more intuitive style.

The psychometric properties of the CSI instrument are documented by Allinson and Hayes (1996). From a sample of 1000 participants, they report a mean score of 38.5. Furthermore, graphical inspection and a Kolmogorov-Smirnov ‘goodness of fit’ test suggest that the test scores are normally distributed. Test-retest reliability of the instrument is also sound (r = 0.90, p <0.001), and mean scores of 34.60 and 35.40 indicate no significant changes over time (t = 0.82, p > 0.05). Finally, internal consistency scores measured by Cronbach’s alpha taken from seven independent samples range from .84 to .92. The construct validity of the CSI has also been reported by Allinson and Hayes (1996). They report statistically significant relationships between the CSI and scores on the Myers Briggs Type indicator. For example, the CSI correlated positively with the extroversion – introversion (r = 0.57, p < 0.001), dimension and correlated negatively with the sensing - intuitive (r = - 0.41, p < 0.05) and judgement - perception (r = - 0.41, p < 0.01) dimensions of this instrument.

2.3.2 Classroom community index (Rovai, 2002)

The Classroom Community Index is a self-report instrument consisting of 40 items, requiring a response on a 5-point Likert-scale ranging from strongly agree to strongly disagree. Scores on the questionnaire range from 0 – 160, with low scores reflecting a weak sense of community and high scores reflecting a strong one. The questionnaire also features four subscales of spirit, trust, interaction and learning with 10 items measuring each and scores ranging from 0 to 40. Rovai (2002) reports a high degree of face validity of the instrument, in that the items appear to measure what is needed to assess community. Internal consistency estimates using Cronbach’s alpha as reported by Rovai (2001) reached .96 for the total scale, .90 for the spirit subscale, .84 for the trust subscale, .84 for the interaction subscale and .88 for the learning subscale.

3. Results

3.1 The relationship between performance on coursework assignments and performance on the MCQs

Clearly students who had attempted more of the MCQs would have scored more than those who attempted less. Therefore for the purpose of data analysis, the mean and not total MCQ scores were used, and placed in the following categories. MCQ scores of between 1 and 3.4 were assigned to category 1, scores between 3.5 and 3.9 were assigned to category 2 and scores between 4 and 5 were assigned to category 3. This system of data analysis ensured that each category contained approximately 30% of participants. A one-way analysis of variance was performed on each assignment score and the mean assignment score for each MCQ category. However, no significant effects were observed.

3.2 The relationship between performance on coursework assignments and engagement with the MCQs

The analysis above illustrates that performance on coursework assignments was not related to mean performance on the MCQs, and the next part of the analysis assesses whether engagement, that is the number of MCQ tests attempted by participants was related to
performance on their coursework assignments. The MCQs were set after each of a series of six lectures and therefore students could have attempted anything between 0 and 6 MCQs. A one-way analysis of variance was performed on each assignment score for the number of MCQs attempted. A significant effect was evident only for coursework assignment three (F, (82, 5) = 2.49, p = 0.04). Figure 2 shows coursework assignment scores for each MCQ category for assignment 3 and illustrates that those who attempted 4 or more MCQs scored higher on coursework assignment 3, whereas those who attempted 3 or less scored lower on coursework assignment 3.

3.2.1 The relationship between performance on coursework assignments and classroom community scores

In order to investigate the relationship between coursework assignments and classroom community scores, the community scores were subdivided into three categories, low community scores (category 1), medium community scores (category 2) and high community scores (category 3). A one-way analysis of variance was performed for coursework assignment scores for each category of the classroom community questionnaire, (that is high, medium and low). An effect approaching significance was observed for the spirit subcategory of the community scale and only for assignment 3, (F (2, 72) = 2.63, p = 0.07). This is illustrated graphically in Figure 3. No significant effects were observed for coursework assignment scores for any of the other community categories.

3.3 The relationship between community scores and MCQ engagement

The third research question looked at the relationship between community scores and MCQ engagement. A one-way analysis of variance was performed on the community scores for each category of MCQ engagement as outlined above. However, no significant effects were observed for MCQ engagement and community scores.

3.4 The relationship between cognitive style and performance

The final research question centred on an analysis of the relationship between cognitive style and coursework performance. For the purpose of data analysis in this study, cognitive style was divided into three categories. A one-way analysis of variance was carried out, and revealed a significant effect between coursework performance and cognitive style, only for coursework assignment 3 (F (2, 36) = 3.67, p = 0.03). In this case, analytics scored highest. This is shown in more specifically in Figure 4.
4. Discussion

This study sought to investigate several issues related to interim assessment and the results are discussed in the following. Firstly the results showed no relationship between performance on the coursework assignments and performance on the online MCQs. The MCQ categories were very narrow and this may account for the lack of any observable differences here. What is possibly more critical is the relationship between performance on the coursework assignments and engagement with the MCQ system. Here the results showed a difference in that students who attempted 4 or more of the six MCQ tests scored better on assignment 3 than those who attempted 3 or less MCQs. This would appear to suggest that students who perhaps engaged more with the course generally were likely to perform better in coursework. Why this is only true for coursework 3 is possibly because this coursework was a more substantial piece of work than the first two.

This study also sought to look at the concept of classroom community, and the relationship between this and performance on coursework assignments. The results showed that students with a high spirit score on the community index performed better on coursework assignment 3. As described above, ‘spirit’ is the feeling of belonging to and acceptance of a group identity. This refers to the recognition of membership of a community and the feelings of cohesion that develops amongst learners in a group as a result of this. It appears then that a feeling of belonging to a group is essential for good performance. However, there would appear to be no relationship between classroom community scores and MCQ engagement. In line with studies, which show a relationship between cognitive style and academic performance, this study also illustrated such a relationship. Here analytics as defined by the Cognitive Styles Index performed best on assignment 3, with no difference in performance between learners of different cognitive styles in the other coursework elements. The consistent finding here is for a difference to be evident on assignment 3. As mentioned above, assignment 3 was a more substantial piece of work, and this may account for the difference observed here. A further possible interpretation is that differences in ability between students were beginning to become evident at the time they took the third assignment. However, it also possible that assignment 3 was an assignment, which differentiated between students on ability, and this, is something, which is worthy of further investigation.

5. Conclusion

In conclusion, the general finding from this study showed several factors determined good performance on coursework assignments. These were engagement with the course in terms of the amount of online assessment attempted, classroom community, and cognitive style. It would therefore seem reasonable to consider these factors in the design of course material.

References


Developing the Communities of Practice, Framework for On-Line Learning

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Abstract: Doctoral research considered whether healthcare students were able to develop characteristics of Communities of Practice when engaged in an interprofessional online module. Using a case study approach the research included two phases. Within phase one a questionnaire was administered to the group of 109 healthcare students. These were analysed to gain information on which to base sampling for the subsequent phase. Phase two employed three strands of data collection; five students completed an online diary, the online interaction of seven students was captured on a discussion board and three students were interviewed. Data were analysed using a form of pattern matching. The results suggested students were able to develop the essential elements of Communities of Practice. This was not uniformly seen however, and particular issues emerged for the online community.

This paper focuses on discussing the contribution of the research to the development of the Communities of Practice framework for online learning. The discussion will review the main findings of the research, showing how these have led to the development of the theory. It offers an augmented framework, in which the elements of mutual engagement, joint enterprise and shared repertoire are enhanced to include those facets necessary to support an online learning community. Finally, it is suggested that the augmented framework may have applicability to other professional groups engaging in online learning and working, with consideration given to how it might support e-based communities.

Keywords: Online learning, communities of practice, higher education, case study research

1. Introduction

The Communities of Practice (CoP) framework (Wenger 1998) was employed as the theoretical underpinning for this doctoral study, which used a case study approach (Yin 1994) to consider whether students of the health care professions might develop online CoP as part of higher education study. This paper considers the theoretical basis of the learning model as a social and situated learning theory, reviewing the main components of community; mutual engagement, joint enterprise and shared repertoire. The application of the framework to online learning (OLL) contexts is considered, along with its use within this study. The discussion presents study findings, proposing an augmented framework that might be employed to support online learning.

2. Research context

This case study was centred in a higher education institution, drawing on a sample of final year nursing (adult, children's and mental health branches), radiography and radiotherapy students based within a faculty of health and social care. The faculty culture supports online learning, evidenced in its learning and teaching strategy, investment in a team of technical and design staff to support e-learning development and a staff development programme including authoring, implementation and supporting e-based delivery. Within the final year undergraduate pre-registration curriculum, an Interprofessional module (IP3) forms a compulsory component for nursing and allied health profession students, studying towards either a diploma (nurses) or honours degree (nurses and allied health professions). With the exception of a face-to-face introductory session, the entire module is supported online within the Blackboard virtual learning environment (VLE). Using a constructivist approach to enquiry-based learning, groups of up to eight student's work with a facilitator to address an initial trigger question (see Hughes et al 2004). Over a period of eight weeks the students engage in online discussions through the discussion board and virtual classroom, submitting individual work online throughout the module and providing peer feedback that contributes to the final module assessment.

3. Theoretical basis

Lave and Wenger (1991) initially espoused learning as a situated activity, employing the phrase, ‘Legitimate Peripheral Participation’. Learners were seen to participate in a community of practitioners and are assimilated into the socio-cultural practices of the community, gaining competence through knowledge and skill development acquired from those positioned as masters (Lave and Wenger 1991). This view of learning resurrected a model of apprenticeship and work-related learning, that was developed as a social learning framework to include four components; community, identity, meaning and practice (Wenger 1998). Meaning is described as participation and reification, which is historically and contextually bound, constituting learning from...
negotiated experience and participation in the community. Practice, learning as doing, involves participation with the community, with the aim of achieving shared goals. Reification, through the use of objects, shapes experiences and contributes to identity formation, with identity seen as learning as becoming. Community is then referred to as learning as belonging, where the community is the learning context and has three essential components: mutual engagement, joint enterprise and shared repertoire.

The model is also viewed as a situated learning theory as it describes learning in social and situated contexts, especially in the workplace (Fowler and Mayes 1999, Fox 2000, Warhurst 2003). Indeed, Lave and Wenger (1991) articulate a view of situated learning as, ‘an integral and inseparable aspect of social practice’ (p.31), which is captured in their descriptions of ‘Legitimate Peripheral Participation.’ Fowler and Mayes (1999) suggest this view of situated learning is social anthropological, where a wide social context is expounded and the CoP emphasises the relationship of the practitioner with members of the CoP, which ultimately shapes the individual’s identity. This concurs with the views of Brown and Duguid (2002) who suggest situated learning is ‘knowing how to be in practice’, rather than ‘knowing about practice’ (p.138), and thus involves a process of identity development for the newcomer through participation in the practice of the community.

4. Theory: Research underpinnings

The development of the theory was based on five studies of apprenticeship discussed by Lave and Wenger (1991). These included midwives in Mexico, Vai and Gola tailors in Liberia, quartermasters in the United States of America (USA), supermarket butchers in the USA and Alcoholics Anonymous (AA). Jordan’s (1989) study of Yucatec midwives described family tradition as the basis of learning. Midwifery was part of daily life for young girls, observing and listening to stories from Mothers and Grandmothers until they were able to deliver babies and act as competent midwives themselves. Formal teaching was not central to the learning, but participation was the way of learning the art and science of midwifery. Lave and Wenger (1991) comment on the variation seen in the forms of apprenticeship studied, where the tailors had a formal sponsored relationship with their masters, quartermasters and butchers follow training programmes and the membership of AA developed through demonstrated commitment to the community.

Becoming a member of a CoP involves learner engagement with the social processes of the community and its tools of the trade or artefacts. Developing competence in knowledge and skill is important in identity formation of the newcomer, who becomes part of the reproductive cycle of the CoP. This position seems to support commonality rather than diversity within the CoP, and has led to some criticism of CoP aiming to perpetuate communities (Eraut, 2003), rather than supporting growth and change.

5. Community dimensions

Wenger’s (1998) conceptual framework sees practice as central to the community, as it is through practice that relationships are formed and identities are developed. There are three dimensions described as essential to a community (Wenger 1998); mutual engagement, joint enterprise and shared repertoire. This research explored whether such dimensions were evident in an online environment, where the community was composed of students working virtually. Mutual engagement is the basis for relationships necessary to the functioning of the CoP. It involves regular interaction of the members, who negotiate meaning of practice within the community. The practice does not reside in artefacts, though may employ computers or books. This interaction might be through formal meetings or informal exchange, which can enable engagement and act to maintain the community. Within an online community, engagement will require online communication and ongoing maintenance through e-mail, discussion boards and virtual classrooms. Wenger (1998) goes on to suggest communities are not homogenous, but are composed of diverse individuals, yet through working together they will influence each other’s functioning within the community. Individuals will create their own identities that function within the community through mutual engagement, a sharing of practice.

The students involved in this study are members of different professional communities, nursing, radiography and radiotherapy, though are expected to work within an interprofessional community, where they make complementary contributions in caring for patients. Mutual engagement will require sharing of their understanding of professional practice and the creation of relationships between the members that can work to the benefit of the community and its patients. It is anticipated that the community would not necessarily live in harmony, but that there can be disagreement and conflict, yet there is concern that if commonality is favoured, this may limit diversity and conflict may be ignored.
Joint enterprise refers to a process that maintains the existence of the CoP. It is not merely about sharing goals, but a negotiated enterprise, involving mutual accountability (Wenger 1998). In an OLL context, this would require students negotiating ways of working towards communally agreed enterprise, within the constraints of an OLL environment. This does not mean all the students must share the same view, but must negotiate their enterprise. Negotiating joint enterprise manifests relations of mutual accountability within the CoP. Working in a mutually accountable way would require a conscious concern about their engagement with OLL. There should be a sense of responsibility as individuals and as a community, with members working to the benefit of the CoP and with concern for themselves and other members. Mutual accountability might be reified by ground rules set by the students at the start of the module, assessment goals to be achieved and limitations of the VLE. Shared repertoire might include developed routines, language, ways of working and stories within the practice of the community, generated through negotiating meaning (Wenger 1998). It is thought to include aspects of participation and reification. Actions and artefacts have histories of interpretation though it is suggested that they do not constrain meaning, but allow negotiation of new meaning and dynamic development through sustained engagement in the community. This aspect of a CoP tends to suggest longevity. Indeed, Fowler and Mayes (1999) feel CoP have a long term and stable perspective to them, which might restrict their use in more transient learning environments. It should be noted however, that research by Rogers (2000) discussed later, was conducted during a three-week online course and suggested the dimensions of a CoP were present.

6. Communities of practice in online learning

The development of a community of online learners working collaboratively within a constructivist-learning environment is discussed within the literature (see Palloff and Pratt 1999, Garrison and Anderson 2003), yet not all students seem to confirm the development of such a community of learning. Orey et al (2003) in the USA reports the findings of interviews with participants of an OLL course. Limited by the very small sample of two males and one female, they describe interactions with coaches external to the learning group, engaging with them rather than forming a community of learners with tutors or fellow students.

Earlier ethnographic research by Spitler and Gallivan (1999) also in the USA, employed Lave and Wenger’s (1991) ‘Legitimate Peripheral Participation,’ to consider how knowledge workers learnt their job within a firm of management consultants, also exploring the role of IT in learning. Thirty formal staff interviews and observations recorded evidence of mentorship and the importance of learning on the job, suggesting CoP had a significance influence on knowledge workers within this isolated example. Somekh and Pearson (2000) used Wenger’s (1998) framework to analyse a European research project group linked by electronic communication and occasional face-to-face meetings, considering children’s representation of information and communication technology (ICT). Presentation of the findings at conference revealed the CoP did not function easily when reliant on electronic communication. Dispersed working confounded the negotiation of joint enterprise; agreed deadlines were frequently missed as they failed to register in people’s consciousness. Sharing a work environment would seem to act as a reminder of deadlines, an impetus missing from electronically linked communities. Shared repertoires and histories of the research partners also created tensions in negotiating a shared understanding of the research approach used, action research. This meant mutual engagement was undermined, as negotiated meaning remained illusive.

Rogers (2000), also in the USA, employed a case study methodology in applying the CoP framework to an online educational setting, providing the only previous example of such an application in the current literature. Though the study was limited by recruiting a small sample of 26 teachers and administrators participating in a three-week workshop ‘Teachers of English as a Second or Other Language,’ it offered an analysis of online dialogue. Rogers completed pattern matching and identified elements of the theory, though offers no independent verification of this analysis, an acknowledged weakness of the study. He confirmed the need for further research, whilst concluding the presence of collaborative working and identified Wenger’s concepts of mutual engagement, joint enterprise and shared repertoire in the data. Wegerif (1998) proposed Lave and Wenger’s (1991) framework of ‘Legitimate Peripheral Participation’ could be used to illuminate the relationship seen in a study of 21 Open University students studying online, between social dimensions of learning and success in a teaching and learning course. A constructivist pedagogy underpinned the course, which Wegerif (1998) felt was supported through developing a sense of community in the group of
learners, seeing social processes as imperative to collaborative learning. Millen and Muller (2001) also in the USA, present research with designers and journalists where knowledge sharing in a CoP was situated in virtual and physical worlds. They highlighted the importance of web-masters and discussion-group moderators in nurturing an online CoP. More recently in the United Kingdom (UK), Murray (2003) describes the possibilities of developing online CoP through engagement in formal e-learning or informal environments. He comments on the potential advantages to nurses forming virtual CoP, referencing an earlier PhD (Murray 2002), for exploring practice, information exchange and potential practice development.

7. Research methodology

In order to address the main research question, ‘How do the essential characteristics of a Community of Practice develop in higher education online learning environments?’ a case study approach (Yin 1994) was adopted. This included two phases, that followed ethical approval gained through the University and faculty ethics committees and piloting of the data collection tools. Firstly, a questionnaire was employed to gain information about the characteristics of the student group (n=109), exploring gender, age, and previous computer use for learning and perceived confidence in use. In so doing it reflected a number of issues related to computer use identified in the literature (Boyle and Wambach 2001, Barrett and Lally 1999). Descriptive analysis of the questionnaire identified frequencies of response and supported the identification of the sample used in the second phase that included three data collection strands. The sample included both males and females, aged between 18 and 49, accessing computers from home, university and other sites. Representing the different branches of nursing, radiography and radiotherapy, they also presented perceived differences in confidence levels in computer use and reported various levels of experience of OLL.

As part of the second phase, seven students were grouped and consented to allow collection and analysis of their discussion board data across the six weeks of the module delivery (327 postings in total). Five students were asked to complete weekly online diaries and three students were interviewed after completion of the module. The data was analysed using a form of pattern-matching (Yin 1994), employing a matrix of categories identified from Wenger’s framework (1998), as an approach to data analysis suggested by Miles and Huberman (1994). The data was analysed by matching verbatim and text data to the categories.

8. Research findings

The data suggests that some students were able to develop elements of mutual engagement, joint enterprise and shared repertoire. Students of the healthcare professions were therefore able to develop the essential characteristics of a CoP in higher education online learning environments, though this was not uniformly seen and a number of issues peculiar to online CoP emerged.

8.1 Mutual engagement

Mutual engagement was facilitated in a number of groups, with formal discussion and social discourse seen. Early engagement is viewed as important to online learning and teaching (Salmon 2004). Online exchange did however hold limitations, and the groups tended to use the virtual classroom to support negotiation and decision-making. Access issues were also evident. These resulted from technical problems as reported in other research (Gillis et al 2000) and a lack of IT skills amongst some students. Those without computer and Internet facilities at home were unable to benefit from the flexibility and convenience that online learning is reported to offer (Martyr 1998, Andrusyszyn et al 1999, Geibert 2000, Atack 2003).

‘. Me and computers do not mix, having written this for the second time because it crashed on me!!’ (DipHE Adult nurse)

‘I think I lost nearly two stone walking to Uni, that’s the biggest advantage of online learning. HA HA HA.’ (DipHE Adult nurse)

There was evidence that professional and personal identities were defined online, though a lack of physical presence in the learning environment resulted in problems in identity recognition for some. Assumptions were made about the composition of the group and there were claims from those students interviewed, that they had presented themselves differently online than they would in a face-to-face learning environment.

‘Wow! I would never have guessed that English was not your first language.’(BSc Radiography)

‘At the start of a classroom experience I would have been quieter. With this I felt I had to go on at the start and say, “hello, this is me!” and get on with it.’ (BSc Child nurse)
8.2 Joint enterprise

Joint enterprise was again evidenced, though the degree to which this occurred varied, with some students feeling this was not achieved. Ryan et al (1999) found the immediacy of classroom delivery was important in comparisons with web-based delivery. Students in the study missed the immediacy of face-to-face interaction, particularly when the groups were trying to negotiate endeavour.

‘They used the virtual classroom to discuss the guidelines. It was clear it was going to need a lot of negotiation.’ (BSc Child nurse)

There were mixed accounts of group interactions, with some implying students were too polite, unable to disagree and negotiate, whereas other students reported open disagreement and strong negotiation in their groups. Acceptance of accountability for group endeavours also varied, with some students seeming to avoid commitment to their group, preferring to pursue autonomous working.

‘People appear to be extremely polite when speaking over the Internet and I wonder if this is going to interfere with getting down to the nitty gritty of what we actually have to achieve.’ (BSc Radiotherapy)

‘I do feel that I haven’t has much group interaction at all from this module.’ (BSc Adult nurse)

‘As I mentioned earlier, there only seem to be myself and two others who are pulling our weight!’ (DipHE Mental Health nurse)

Technical issues and skills, as previously seen (Ragoonaden and Bordeleau 2000), may have adversely affected the engagement of students in online learning. It is suggested that differing technological skills affect group collaboration (Ge et al 2000). A lack of trust amongst group members can contribute to difficulties in-group functioning (Wegerif 1998, Murphy et al 2000). Individuals can also be reluctant to engage in online groups (Brown 2001). A perceived lack of time for engagement may also be an inhibiting factor (Conole et al 2002).

8.3 Shared repertoire

It is postulated that OLL environments with a brief existence may not have the longevity required to develop shared repertoire (Fowler and Mayes 1999). Attempts to review this are compounded by the difficulties of accessing evidence of routines, language, and ways of working online. Despite these concerns, a number of students had reached new understandings of interprofessional working and of IT skills, developed through community engagement.

‘I learnt more about the other professions, especially radiotherapy.’ (Dip HE adult nurse)

Some support for the development of shared repertoire resultant from online group learning is therefore evident. There was evidence of humour, shared discourse and some presentation of shared routines online.

‘Thanks for saying hi the other day on the video conferencing .my class was wondering what was going on!!!’ (Dip HE adult nurse)

in reply: ‘Ahhh just tell em you’re me toy boy’ (BSc Adult nurse)

This was not uniformly developed however; with a number of students claiming autonomous working and learning had dominated their experience.

‘We didn’t discuss a lot in my group and I tended to get on with it.’ (BSc Child nurse)

Autonomous working can be the preference of students working in online groups, which it is suggested can particularly be the case if collaborative elements of online learning are not seen as relevant or focussed on assessment (Ragoonaden and Bordeleau 2000). The findings offer the potential to develop Wenger’s (1998) framework, expanding it for use in OLL environments. Aspects of the social learning model and the three essential components of community are being reviewed to include those factors requiring consideration when applying the framework to OLL contexts.

9. Theoretical framework development

Uniquely this research has considered whether students of the healthcare professions could create an online CoP as part of a web-based learning experience. Its focus on the three components of essential for community functioning; mutual engagement, joint enterprise and shared repertoire, have led to the discovery of emergent issues to inform the development of online communities.

9.1 Developing mutual engagement

The student community working in a virtual environment needs to overcome access issues not normally present in a physically located CoP. To support mutual engagement the CoP members required IT skills and resources, both hardware and software, to engage in the virtual community. The study also found students required access to
all components of the VLE, using the virtual classroom for synchronous discussion (real time interactive communication), crucial at times when the members were required to make decisions. On these occasions more ‘instant’ communication than that offered through asynchronous (not real time) vehicles such as the discussion board or email, was essential. These findings suggest that an online community will need to ensure participants have the technological provision and necessary IT skills to support engagement.

9.2 Developing joint enterprise
The students were able to present and develop individual identities online as part of joint enterprise. Professional identities of the healthcare students were shared and understandings of professional roles were enhanced. However, data also exposed the potential for identities to remain hidden. Examples included the presentation of gender and culture that could remain illusive to fellow community members. Additionally, students confirmed that their presentation online differed from that offered in the face-to-face learning environment, creating different personas. The emergence of different online personas, originally presented by Turkle (1997), suggested alternative identities could be portrayed in an environment where individuals might remain hidden. The interview data in particular suggested students felt communication online was curtailed due to word-processing difficulties. This hampered the openness of communication, resultant in a feeling that they were presenting different personalities online. There was also evidence of individuals failing to engage in community endeavour, with some students very obviously preferring to work autonomously.

9.3 Developing shared repertoire
Identifying elements of shared repertoire proved problematic in the analysis of the online environment, which lacked the richness that might be observed in a physically located CoP, where presentations of gestures, nuances, routines, stories are manifest. Additionally, IP3 lacked longevity, which seemed to lessen the opportunities for the development of shared understanding. It was clear however, that engagement in the OLL environment supported the development of IT skills amongst many students, with noted development in the use of various components of the VLE. The data also demonstrated IP learning, with a number of students discovering more about other healthcare professions from fellow community members. As the case study is limited to one group, it is difficult to know whether this learning was a feature particular to this group or whether this might be seen in other cohorts of students studying IP3.

9.4 An augmented framework
In developing Wenger’s (1998) dimensions of CoP for the online environment due cognisance of the above facets needed consideration. The development and augmentation of the framework provided by Wenger (1998, p.73) is shown in figure 1.

![Figure 1: Augmented theoretical framework. Adapted from Wenger 1998:78](image-url)
It presents the additional facets required of the CoP framework when applied to online environments. The model includes the three main components arranged in a structure that adapts Wenger’s (1998) original presentation, with mutual engagement, joint enterprise and shared repertoire being positioned with the key facets related to each outlined in a ‘square’. The model has been augmented to include the addition of a second ‘square’ to include the additional facets required within an online CoP. Mutual engagement includes; IT skills, confidence in IT use, access to computer hardware and software, VLE access and technical support. Joint enterprise sees the development of trust and support of identity presentation as an added facet of online community working, with shared repertoire suggesting longevity of the community is required. The additional ‘squares’ are attached using interrupted lines to depict the possibility of the CoP continuing to exist in physical environments, not requiring the online facets. The structure also offers scope for the online facets to support physically located contexts as well. For example, development of trust, whilst identified as important to the OLL CoP, is likely to impact on a physically located CoP.

10. Conclusion

The results of this study suggest that nursing, radiography and radiotherapy students learning online were able to demonstrate the development of mutual engagement, joint enterprise and shared repertoire, as elements of Community of Practice. This was not uniform and issues associated with operating in an online community enabled the identification of the additional facets required to support such communities, as presented in the augmented framework. The findings also raise ongoing concerns of interest to e-learning proponents and implementers. These relate to enabling access to the environment and supporting the development of computing skills. Issues of course design are also raised, requiring the linking of activities to assessment processes that necessitate the involvement of all members. Course design should ideally require students to explore each other’s histories and values, limiting different persona presentation. Course longevity should also be considered. Despite these issues it is suggested that creating online communities of practice will allow the transcendence of geographical boundaries amongst learners, as seen with this interprofessional group of healthcare students. It has the potential to facilitate nationally and internationally based pursuit of academic endeavour and practice development.


References

Using Conceptual Lattices to Represent Fine Granular Learning Objects through SCORM Meta-Objects

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Abstract: Ideally, learning resources should be built over a shared pool of fine reusable granular learning objects. However, in order to avoid contextual lacks, dynamic creation of such resources would mostly rely on the conceptual relationships among learning objects inside a repository. These conceptual relationships, as well as the learning objects creation, are best established if students’ learning styles are considered. Common standards like Sharable Content Object Reference Model (SCORM) do not have tools to provide conceptual relationships among fine granular learning objects. This paper presents a conceptual lattice-based architecture for using SCORM to provide an effective mapping of conceptual relationships among learning objects.

Keywords: learning objects, conceptual lattices, SCORM, granularity.

1. Introduction

Learning objects (LOs) constitute any digital entity that can be used, reused or even referenced during a technology-mediated educational process (IEEE-LOM, n.d.; Millar, 2003; Wiley, 2000). The proposition of learning objects configures the possibilities reusability, manageability, interoperability, and accessibility (South and Monson, 2000). Granularity becomes a key concept for LOs when they are designed to be reused in different contexts. LO granularity is related to the level of detail contained in a LO, as well as its size, decomposability and potential of reuse. Finer levels of granularity are desirable since the smaller an LO is, the more likely it is to be reused in different contexts. In addition, learning object repositories constitute resource providers that contain and manage LOs in order to make them referable, accessible and distributed in large scale. This mechanism can be extended and become richer through the establishment of conceptual modelling of relationships which could include learning styles (Curry, 1987). Learning styles describe categorisation ranges that take into account the ways people naturally – and unconsciously – perceive information and build knowledge through them. However, the implementation of the presented characteristics constitutes a challenge that involves different proposals of metadata standards, such as SCORM (Sharable Content Object Reference Model) (ADL, n.d.), IMS (Instructional Management Systems) [10], Dublin Core (DCMI, 2004) or LOM (Learning Object Meta-Data) (IEEE-LOM, n.d.).

Currently, the major scheme used and supported by LORs is SCORM (ADL, n.d.). This standard tends to be globally accepted, considering the current support it receives by learning objects repositories. This standard is based on three basic documents: the Content Aggregation Model, the Run-Time Environment and the Sequence and Navigation Model. The Content Aggregation Model (CAM) allows quantitative and qualitative annotations about learning objects. The Run-Time Environment (RTE) defines the operational environment that is necessary for the object execution. The Sequencing and Navigation (SN) model defines a linear order for the exhibition of LOs. Particularly, the SN document is largely discussed in literature, especially considering the Activity Trees limitations. Basically, the Activity Trees are responsible for the navigation among objects. The navigation scheme defined by these trees is interpreted by the Learning Management System (LMS) in a traversal order. The current scheme could actually restrict the apprentice navigation through the objects. The navigation pathway of this model is limited because it does not consider the necessities of learning personalisation, especially the differences related to how apprentices interact or answer to a specific learning environment. According to this, LORs need to consider the representation of learning styles diversity to enhance the effectiveness of educational processes with ICTs (Information and Communication Technologies). This paper proposes a navigational scheme among SCORM objects based on the Conceptual Lattices Theory and Learning Styles concepts using a dynamical graph navigation transformation. This proposal includes the introduction of annotations and links with semantic structure via XLink (Wilde and
Lowe, 2002) technology within the SCORM objects. This allows a personalised and non-linear treatment for point-to-point navigations between objects.

2. Granularity of learning objects

Firstly, we consider the following fact: the usual process to develop digital learning processes results in large monolithic content. This content is hard to be reused because it lacks granularity. On the other hand, such content could be described as a well-structured, highly reusable, low-coupled learning objects set that could be arranged in order to provide a more adaptive, learner-centred content. This could be explained by some essential elements: first of all, digital learning content is often planned in an ad hoc way, since its content is too much problem-specific, being driven to a given knowledge domain. Besides, such development often uses tools and techniques that usually do not separate content from presentation. Learning objects’ development usually includes a variety of tasks and procedures, such as instructional and hypermedia design, text analysis and production. Furthermore, there are other tasks to be performed, like course authoring, software tools development, content integration and evaluation, training and establishment of a lifelong computer-mediated learning organisational culture. Defining a reusable architecture for more effective learning objects retrieval would noticeably diminish costs related to the development of new courses, thus contributing to make the task of creating new learning objects faster through reuse.

Besides, relationships among LOs must be equally ubiquitous through different levels of granularity. These relationships must be transparent, being kept away from the courses developers’ point of view. These requirements could be fulfilled by applying techniques like conceptual lattices (Davey and Priestley, 2002), whose precise building and navigation relies on psychological and educational theories, like Kolb’s Learning Styles Theory (1984).

3. Conceptual lattices

The theory of partially ordered sets and lattices (Davey and Priestley, 2002) has been successfully applied to the modelling of hierarchical systems and has produced many contributions in several computational areas as Artificial Intelligence, Category Theory, Semantics of Programming Languages and Concurrency Theory. The concept definition involves a complex philosophical question. However, a concept is formally determined by an extension and an intension. All objects belonging to a concept form an extension and an intension is an attribute set shared by such objects. Normally, the enumeration of all objects and attributes related to a concept represents a hard, sometimes impossible task. Thus, in many practical cases, the set of objects and attributes is restricted to discrete and finite ones. In order to clarify the preceding definitions, let us consider a context to learning concepts about the Solar System:

Table 1. Context adapted from Davey and Pristley (2002) for Learning of Solar System. Objects are formed by Planets and attributes are related to Astronomical Observations of size, distance from sun and moon's Presence/Absence.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Size</th>
<th>Distance from Sun</th>
<th>Does it have a moon?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>small</td>
<td>near</td>
<td>no</td>
</tr>
<tr>
<td>Venus</td>
<td>small</td>
<td>near</td>
<td>no</td>
</tr>
<tr>
<td>Earth</td>
<td>small</td>
<td>near</td>
<td>yes</td>
</tr>
<tr>
<td>Mars</td>
<td>small</td>
<td>near</td>
<td>yes</td>
</tr>
<tr>
<td>Jupiter</td>
<td>big</td>
<td>far</td>
<td>yes</td>
</tr>
<tr>
<td>Saturn</td>
<td>big</td>
<td>far</td>
<td>yes</td>
</tr>
<tr>
<td>Uranus</td>
<td>medium</td>
<td>far</td>
<td>yes</td>
</tr>
<tr>
<td>Neptune</td>
<td>medium</td>
<td>far</td>
<td>yes</td>
</tr>
<tr>
<td>Pluto</td>
<td>medium</td>
<td>far</td>
<td>yes</td>
</tr>
</tbody>
</table>

Conceptual lattices are better visualised using a Hasse Diagram, a directed graph that exhibits order-covering properties through a hierarchical diagram. Theoretically, two Hasse Diagrams would be necessary in order to represent the possible orderings: using objects and attributes. Figure 1 depicts objects and attributes related to lattices from a Solar System context, without edge orientation:

Figure 1: Combined Hasse Diagram related to Solar System context. Annotations below nodes
represent object subsets, while those above indicate attribute subsets.

The combined diagram allows navigation in both vertical directions: ascendant and descendant. The ascendant navigation starts on lattice lowermost and it allows an easy way of obtain objects. For instance, in the preceding diagram the lowermost has no related object (empty set) while all the planets arise in the next order level. The central node, even without annotation, inherits objects belonging to the level immediately below (Earth, Mars and Pluto), obeying the inclusion ordering. The lattice utmost in the ascendant navigation contains, by inheritance, all objects in the context.

The descendant navigation allows the easy attainment of attributes. In the lowest part of the navigation we have an empty set again since all objects in the context share no common attribute subset. The central node has no annotation as in the ascendant navigation, but using inheritance we conclude that it is small and owns a moon. It is not difficult to see that the utmost of descendant navigation presents all attributes in the context.

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4. Learning styles

According to Cognitive Psychology, learning styles represent the individual preferred ways of perceiving and processing information, which are the responses to educational stimuli (Alonso, 1993). In this case, as Curry (1987) has pointed, the analytical diagnosis of learning styles considers theoretical models that emphasise the preferences related to instructional context, information process, social interaction or even individual personality. David Kolb (1984) developed a proposal that considers this framework. His proposal of learning styles representation is based on a bi-dimensional scale that results in four categories: converger, assimilator, diverger and accommodator.

The converger learner is an inquirer and has a better performance in situations that involve a correct response, problem solving, decision-making, and deductive hypothetical reasoning. The assimilator apprentice presents inductive reasoning and is supposed to develop theoretical models from multiple observations and analyse situation from different points of view. The diverger student is an observer that uses reflection and feeling to construct models and presents high performance in applications that involve lateral thought. Finally, the accommodator learner appreciates the activities that include creativity, autonomy, and presents high degrees of immediate adaptability. Table 1 summarises the key characteristics of Kolb’s classification:

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Learning Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converger</td>
<td>Abstract Concept</td>
</tr>
<tr>
<td></td>
<td>Active Experimentation</td>
</tr>
<tr>
<td>Assimilator</td>
<td>Abstract Concept</td>
</tr>
<tr>
<td></td>
<td>Reflexive Observation</td>
</tr>
<tr>
<td>Diverger</td>
<td>Concrete Experience</td>
</tr>
<tr>
<td></td>
<td>Reflexive Observation</td>
</tr>
<tr>
<td>Accommodator</td>
<td>Concrete Experience</td>
</tr>
<tr>
<td></td>
<td>Active Experimentation</td>
</tr>
</tbody>
</table>

These elements collaborate to organise, structure or select the learning objects in a LOR that are more appropriate for a given learning context and offer subsidies for the establishment of educational approaches. Besides, it is possible to use instructional design elements to constitute a systemic educational architecture. Considering different theories, heuristics and methods for analysis and definition of guidelines from learning styles that personalise learning experience (Mustaro et al., 2006). From combining learning styles characteristics and instructional design framework it is possible to establish didactical proposals for learners. In the converger case, the activities can be associated to problem solving situations that present a single answer or choice the best solution from structured tasks that consider errors as elements of learning process. For the assimilator apprentice, one perspective includes development of exercises that involve logic steps and theoretical model for problem solving. The diverger learner is characterised by his questioning behaviour, being able to establish relationships between content, previous experiences, etc. when manipulating a case study, for example. At last but not least, the accommodator student is creative and presents interest for working in solving of real problems or role-playing. In this case accommodator learners can transpose scene characteristics and generalise them in other contexts. To analyse this scenario and determine a person's learning style it is necessary to use the Kolb instrument of evaluation (Learning Style Inventory – LSI), which is based on identification of apprentices' perceptual and processing preferences.

With these pieces of information, it is possible to model LORs. However, the computer applications related to identifications of learning styles is not the focus of this paper, however it is necessary to present kinds of learning activities that could be
related to the dimensional model. Concrete Experience Learners’ dimension could be guided by experiment observation, simulation systems, movies or role-playing activities. In the Reflexive Observation dimension, it is possible to develop activities such as guided reading, portfolio writing, conceptual maps elaboration and thematic discussion in groups. Abstract Conceptualisation dimension explores research papers, Computer-Assisted Instructional software (CAI) and other activities that deal with learning individual timing. The last dimension, Active Experimentation, presents trends to explore case studies, assignment problems or laboratory experiments.

The study presented in the following items introduces the proposal of using conceptual lattices to implement SCORM adaptive navigation rules that consider students’ learning styles. The described schema provides information that allows the understanding of students’ distinct ways of learning. From the standpoint of information process preferences, it is possible to design the educational process to use adaptive learning objects with Conceptual Lattice-based SCORM for personalisation of apprentice experience.

5. Conceptual lattices and learning styles

Considering Kolb’s model presented in Section 4, it is possible to infer that convergers and assimilators use structured logical sequences of information to learn. They could use axiomatic logical resources that could be defined by properties (or attributes). Thus, they could develop a complex theory based only in the subject’s properties or axioms. It is also possible to affirm that convergers and assimilators could learn the logical characteristics of the solar system by studying only its properties. Convergers use a simple path through attributes to achieve their objectives. The learning path defined by convergers is depicted in the figure 2. Assimilators can pass twice over a graph node in order revise or rethink some knowledge. Their navigational transformation is shown in figure 3. Again, taking Hasse’s diagram as a viewpoint, divergers and accommodators will follow the ascendant navigation direction, which means, using objects. They will start from the planets (objects) and will traverse their characteristics (attributes). They will repeat this process until they have learned all the planets - the entire Solar System. Their learning paths are depicted in figures 4 and 5.
Figure 5: Accommodators' learning paths through conceptual lattice.

It must be noted that both approaches will present the same result: even by learning through attributes (planets properties) or through fragments (planets as objects), all students will learn the entire content.

6. Metadata standards and fine granular learning objects

IEEE Learning Object Metadata – LOM (n.d.) uses the Aggregation Level to describe "the functional granularity" of a learning object. SCORM also considers different levels of granularity, classifying them in the following scales:

- The smallest level of aggregation, e.g. raw media data or fragments.
- A collection of level 1 learning objects, e.g. a lesson.
- A collection of level 2 learning objects, e.g. a course.
- The largest level of granularity, e.g. a set of courses that lead to a certification.

Wagner (2002) defines five different granularity categories. In this classification, highly atomic LOs are called “content assets”; the next level of granularity refers to "information objects", or "molecular" LOs. SCORM considers assets as a first granularity level. SCOs (Sharable Content Objects SCOs, as well as metadata about aggregation itself and its individual components.

SCORM is a reference model for the packing and aggregation of learning objects allowing their usage from any compatible LMS. The SCORM model was presented by ADL (Advanced Distributed Learning) and it is defined by three documents: Content Aggregation Model (CAM), Run-Time Environment (RTE) e Sequencing and Navigation (SN) (ADL n.d.). The basic unities in SCORM are the SCOs, which represent the learning objects that compose a course structure. The navigation among these objects must be defined in such a way that it can be followed by the LMS. This phase of a SCORM package definition is called content aggregation and it is accomplished by the creation of a XML file with the navigation rules among the objects. Thus, a SCORM package must contain a manifest file according to the IMS Global Learning Consortium rules. The package contains its content declaration, the content navigation order and the placement of the SCOs' physical files. Besides the second granularity level, being self-contained learning objects that meet additional technical requirements needed for interoperability with LMSs. Third SCORM granularity level includes Content Aggregations, which could contain assets or

Besides the manifest and the SCOs' files, the SCORM package includes description files for every SCO in order to facilitate their manipulation. These files are known as meta-data files which basically include information like author, title, version, creation date, technical requirements, educational context and objective. A manifest file could refer to others, called sub-manifest files.

The LMS uses these files to establish the navigation order among SCOs. The Activity Tree defines this order. A learning activity could be a resource ("leaf" activity) or could be composed by different sub-activities. Besides, the activities have start and end points defined, as well as associated final tests. The passing from one activity to the other depends on successful attempts through the final tests. Thus, the sequence followed by the LMS is based on the Activity Tree traversal that is derived from de manifest(s) file(s). This structure, however, is not always the best alternative for a course. Based on this limitation, some work has been presented by researchers to propose alternative sequencing structures.

Different authors have been discussed limitations to the SCORM meta-data model. Abdullah (2004) points out that the SCORM model version 2004 follows the IMS proposal (2004), but it is too simplistic once it does not provide mechanisms for the effective implementation of adaptive learning objects. Gomes (2005) stands out the current standards’ limitations, regarding comprehensive representation of functional learning objects. Simões (2004) proposes a SCORM extension,
which can support transversal information to the learning objects, such as evaluation rules, curriculum or bibliography. Chang (2005) proposes using Petri Nets to represent the SCORM activity tree. The goal is to provide a linear visualisation of the traversed flow, as well as to allow the skipping through some chosen lessons. The authors support that such a scheme may be useful in collaborative environments (that are not covered by SCORM).

7. SCO annotations and links

The navigation among SCOs is highly dependant on the Activity Tree structure. This section proposes an alternative implementation of Activity Trees by introducing XLink navigation annotations directly on SCOs, dispensing further navigation structures on these trees. The previously presented navigation structure for objects and attributes do not depend on linear navigation. In order to map the principles described in this section with minimum impact on SCO annotation, will be adopted the following construction order: annotations in objects and attributes, link introduction among SCO objects and link annotation.

7.1 Annotations in objects and attributes

The annotation process in objects and attributes will be performed in META-DATA section of SCO manifest file, by using the tag keyword available in lom namespace (Davey and Priestley, 2002) and described by the SCORM Content Aggregation Model (SCORM CAM). The given annotation syntax follows:

```xml
<manifest ...
  <metadata>
    <lom:lom>
      <lom:general>
        <lom:keyword> <!-- An object/attribute -->
          <lom:string> object | attribute
          <lom:keyword>
            <lom:string> Object or attribute name
            <lom:keyword>
              <lom:general>
              </lom:general>
            </lom:keyword>
            </lom:string>
          </lom:string>
        </lom:keyword>
      </lom:general>
    </lom:lom>
  </metadata>
</manifest>
```

Each SCO encapsulates a set of objects and attributes. Each object or attribute uses a keyword tag, described by two strings: a type (object or attribute) and a name. The type string is important for inheritance evaluation, which will be performed in the navigation process.

7.2 Links between SCOS and their annotations

The navigation structure between SCOs is still target of intense discussion as showed in the document SCORM Sequencing and Navigation (n.d.). To attend the navigation purposes in the hierarchical model treated in the Section 4, the XLink technology (Wilde and Lowe, 2002) is highly adequate. Links using XLink allow bi-directional navigation, processing rules and multiple directions. Links will be added to SCORM manifest using a new tag inside lom namespace called navigation:

```xml
<manifest ...
  <metadata>
    <lom:lom>
      <lom:general>
        <lom:navigation> <!-- A navigation link -->
          xlink:type = "extended" xlink:to = address of next SCORM object
          xlink:from = address of previous SCORM object
          xlink:arcrole = link processing rule
          xlink:show = "replace" xlink:actuate = "onRequest">
            Navigation text...
        </lom:navigation>
      </lom:general>
    </lom:lom>
  </metadata>
</manifest>
```

Each navigation tag represents a basic navigation unit: we know the previous address (from), the next address (to) and what we must do on the present object (arcrole). As an implementation rule, we use the actuation rule under request (onRequest) and its behaviour should occur by taking the place of the current content (replace).

One of the most important issues related to the proposed link consists of the arc processing role: if we are using an ascendant navigation, the set of valid objects, including the one you are on, is formed by the node itself plus their ancestral nodes; by using a descendant navigation, we consider the attribute related to the node plus their ancestral attributes. Furthermore, it is also possible to verify previous requirements in the navigation, process that resemble the tags in namespace imss (IMSS, n.d.).

Indicating an XML parser, normally based on SAX or DOM processing models, may specify the link-processing role. In this context, treatment roles can be interpreted as concerns that crosscut order relations and could be implemented by using Aspect-Oriented Programming (Kiczales, 1997). This approach allows us to work with an external entity, the aspect, in which we can introduce a complex treatment to arc roles with a low impact.
on SCO structure. Furthermore, we can replace the treatment role without changing the SCO and setting free the LMS to control the navigation task among SCORM objects.

8. The hierarchical structure and SCORM meta-object

The SCORM units built in the previous section will now be organised in a hierarchical structure in order to reflect the conceptual lattice requirements. Lattice nodes are mapped to SCOs and order relationships use links specified with XLink. These elements form a whole unit represented by a manifest file. Each manifest file is an integrating part of a bigger object, called SCORM meta-object or SCO-meta. Two annotations are essential for the SCO-meta: the initial SCO to start the navigation process and the direction to follow. Only the initial SCO will be mapped as a sub-manifest of the SCO-meta. This fact will permit the reduction of necessary space required to store the remaining hierarchy. The initial SCO for navigation purposes, as well as the direction, can be easily implemented in a manifest file by using the tag <organisation>, jointed with the tag <resource>:

```
<manifest>
  ...<organisations>
    <organisation>
      <item identifier="Initial" Identifierref="RInitial" />
    </organisation>
  </organisations>
  <resources>
    <resource identifier="RInitial" href="manifest0.xml" />
  </resources>
</manifest>
```

An initial object in the navigation hierarchy will always be identified with the name Initial, which is placed in the parameter identifier inside the tag item. Finally, the LMS only needs to know the initial SCO and then transfer it to the navigation control. This responsibility delegation allows achieving great flexibility to navigation by associating complex and dynamic behaviors to SCO transitions.

8.1 Learning styles in the SCORM meta-object

Unfortunately, SCORM does not foresee learning styles in the manifest file. However, without a right learning style, the LMS does not know how to pass the navigation control in the lattice. In order to provoke a minimum impact in the manifest file, we propose the usage of the field Parameters in the item tag inside the organisation. We define a field called Style, which could assume the following values: converger, diverger, accommodator or assimilator. The following code exhibits a more complete SCORM metafile including style navigation for a converger learner:

```
<manifest>
  ...
  <organisations>
    <organisation>
      <item identifier="Initial" Identifierref="RInitial"
        Parameters="? Style=converger" />
    </organisation>
  </organisations>
  ...
  <resources>
    <resource identifier="RInitial" href="manifest0.xml" />
  </resources>
</manifest>
```

The Style parameter regulates how the navigation control is performed: with the converger value, we have a strict descendant navigation; by using the assimilator value, we can navigate in both descendant and ascendant direction with attributes; with the diverger value, we have again a strict ascendant direction and, finally, by using the accommodator value we gain two directions with objects.

9. Conclusions and further work

The specification of interoperability, accessibility and reusability in reference models is of great interest for Learning Management Systems development. In particular, the SCORM standard represents a great alternative to encapsulate learning objects data. Besides its general usage, SCORM has some deficiencies as the fact that it lacks sophisticated navigation mechanisms. This paper presented a proposed architecture to navigate through a SCORM objects net via conceptual lattices with dynamical graph navigational transformations. These lattices allow navigation among objects and attributes in a bi-directional way. The architecture is based on the introduction of annotations and links via XLink technology that is highly applied to integrate XML documents. The annotations and links produce a low impact on the current SCORM structure and make possible the building of complex SCORM objects nets through simple constructions. Links among objects could be endowed with qualified semantic processing. Besides, they allow the abstraction of connections as aspects among the manifest files associated with the learning objects and styles.

The approach used in this paper for learning styles respects some learners’ individual
characteristics even if it could be considered a simplistic form to face learning styles. Furthermore, specific learning styles effectively guide a dynamic graph navigational transformation. Future work will include more sophisticated learning styles classifications, as well as the study of more elaborated conceptual models as, for example, hybrid models involving Petri Nets and Conceptual Lattices. Besides, the automatic SCORM objects generation via conceptual lattices and their dynamical rewriting could be a powerful tool to help the learning objects development with high cohesion, fine granularity and high adaptability for different navigational styles. The development of a tool for learning styles discovery is also being planned.

References


