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PERSONALIZED CONTENT PROVISION FOR VIRTUAL LEARNING ENVIRONMENTS VIA THE SEMANTIC WEB

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ABSTRACT

In this paper we discuss how we may personalize e-learning along three distinct axes, namely: teaching and learning pedagogical philosophies, personalized educational processes to taste and the coordination of these processes during execution. In doing so we are concerned with supporting users' choices of educational options in course delivery via the Web services. In the work presented here, we assess the practical needs of learners and tutors and then the main research problems are analysed from a practical and pragmatic point of view. Following on from this the design of an intelligent virtual learning environment (VLE) is described to map a set of extensive didactic paradigms, which is represented by a system model and architecture. In this system, the semantic information of learning units and processes (e.g. the relationships among units) can be described and integrated in terms of various requirements of our users. As a result instructional materials with a wide variety of executional options and conditions can be built. Furthermore, through reassembling the semantics of learning content according to users' new demands, our target audience (both student and content deliverers) can change their particular educational experience dynamically. This VLE can provide high-powered pedagogy-layered personalization - thus enabling new managed e-learning Web services and applications.

Keywords

Teaching and Learning Styles, Personalization, Personalized Creation and Control of Instructional Procedures, E-Learning.

1. INTRODUCTION

The advent of the Semantic Web (Berners-Lee et al, 2001) allows us to revisit afresh the provision of online personalized provision of learning materials. It has been long acknowledge that, "…one size fits all", is not a good option for learners (e.g. Self, 1974; Hartley, 1978) and that the meta-data description, interoperability, and heterogeneous integration of multiple knowledge sources that the Web now affords allows a new look at the provision of Intelligent Tutoring Systems. Traditional approaches to this problem (e.g. Sleeman and Brown, 1983) have typically utilized single knowledge sources with inference engine and history mechanisms to provide some form of user modelling. The advent of the Web means that knowledge can be viewed as distributed from many sources and forms of media. A lesson can therefore be assembled from many locations and reflect various options. The task therefore shifts from creating content to considering how this assembly of content takes place. The work presented here considers this problem of assembly, how we may order the potential media information space, how this ordering is effected by pedagogical philosophy and individuals, and how this could be implemented and evaluated. The paper starts with a review of recent Web-Based Learning, then sets out some of the a priori of this research, namely flexibility in learning philosophies and choice of materials, before introducing a methodology to evaluate the introduction and evaluation of the technological solution described.

2. WEB BASED LEARNING

As Zhu et al (2007) point out, given the leaps that internet technologies have made in the world of e-commerce it is only pertinent to reconsider the advantages that web based delivery in education might deliver. As we shall review in subsequent sections, the goal of computer delivered didactic material is well established (Blackboard, 2002a & b; Sakai, 2011). In the context of Web 2.0 in addition to classical computer and education concepts like being self-paced, readily available, and accepting one size doesn't fit all (e.g. O'Shea and Self, 1983), concepts like top-down user emergent folksonomies (as opposed to concept management system (CMS) categorisation), syndication of 3rd party services, participation, and knowledge sharing have emerged (e.g. after Spaniol et al, 2007). One of the key driving goals of this work is personalisation of service

making it easier for the student to learn and cutting down on potential confusion (Kim, 2007) allowing students to, "…roll their own…" experience whilst reusing existing web material. A less open approach might guide this process based on measures of student ability (Leung and Li, 2006), models of the student behaviour (Hewagamage, 2006) or a combination of student discovery and pedagogical philosophy. Personalisation can also be manifested by the sharing of knowledge not just by individuals but on a peer to peer basis (Eisenstadt et al, 1996; Li et al, 2007; Singh, 2008). This personalisation may be a two way process so that personalisation may be both for the user and for the instructor too (Zhu et al, 2007).

In this paper we consider how to build upon the above within this context, using intelligent schema based technologies grounded in instructional traditions. We shall consider the options available, namely:

- to personalise the manner of the teaching and the learning styles underpinning these;
- to personalise learning and ordering of the material being studied;
- to aggregate material intelligently based on choices made to produce a deliverable curriculum.

A prototype system that sets out to demonstrate the implementation of the above three ideas and is described to illustrate a subset of the above.

2.1 Personalized Teaching and Learning Styles

Teaching and learning styles embrace a set of instructional mechanisms for students to acquire knowledge, experience, and skills, which provide support for(?) a variety of personal and adaptive interactions between staff and students (Wim et al, 2003; Felder et al, 1988 and Felder, 1988). In practise a range of instructional styles are used by students and staff in educational environments. Thus it is important that e-learning systems allow users to create and perform within their preferred pedagogy approach. Over the years, a number of patterns have been proposed to guide this process, from Skinnerian strictness (in 1960's programmed learning) to open ended discovery learning (e.g. LOGO, Papert, 1980). No one theory is embraced here instead we provide a platform to implement a set of such theories. So the question becomes that of how to implement a range of teaching and learning styles on the Web by aggregating different approaches, techniques and devices. The range of these teaching and learning styles and regimes might include some from the following examples.

2.1.1 Imperative teaching and learning

Imperative teaching and learning (e.g. Mosston, 1972) usually means that tutors control everything in instructional environments, such as determining the learning timetable, selecting learning units, learning sequences, learning places, assessment methods and standards of learning results, and the following learning strategies based on these. Classical "chalk and talk" approaches would fit under this category. Alternatively behaviourist based accounts and particularly programmed learning (e.g. Skinner, 1954, 1965) would also fit under this banner. Here the emphasis on feedback is important - desired behaviour can be strengthened by positive feedback and unwanted behaviour suppressed. This technique is still seen in textbooks, in some self-paced computing systems or in approaches that emphasis repetition (e.g. Jones, 2003).

One of the advantages is that instructors can control and manage the interaction. Tutors can provide all the necessary learning materials. On the downside is that students have little freedom to identify their preferred – i.e. personalized - learning materials and processes and so the creativity of students may not be encouraged or engaged.

2.1.2 Collaborative Learning

This is an educational method that provides the opportunity for learners to acquire knowledge, experiences, and skills in the social content of groups working on different topics (Dillenbourg, 1999; Vgotsky, 1934). This learning may be computer supported and based on shared virtual spaces (e.g. Eisenstadt et al, 1996). The advantages and disadvantages of this pattern can be described as follows (Leng et al, 1999):

One of the key advantages is that it is easy for students to communicate with each other to develop understanding of the learning activities designed by staff and/or the learners themselves. Furthermore, tutors can monitor group activities and discussions, identifying and dealing with students' learning problems as they arise. One of the disadvantages is that learners may need to spend a lot of time developing the answers to their questions. Furthermore, students do not have opportunity to select their own learning material as would be appropriate to meet their personal learning styles, as they must work in a collective manner.

2.1.3 Self-evaluation based learning

Self-evaluation (Blanchard, 2002) supports learners by allowing them to make their own observation and assessment of their individual interests, prior to tutors suggesting learning materials and strategies to meet these needs. The advantages and disadvantages of this pattern can be described as follows (MacBeath and McGlynn, 2002):

One advantage is that students may select learning content according to their interests. Learners may assess their results by themselves. If the results do not meet their aims, learners can choose other resources based on the analysis of these results and try again. If students arrive at their goals, they may post their completed work to tutors to get a final evaluation. This method is useful in improving the learning abilities of the tutee. One of the disadvantages of this approach is that most students do not appreciate the standards of assessment of their own performances, as they do not have appropriate skills, experience, and background knowledge to self-assess. Additionally, they tend to focus on what they are interested in without considering whether it is valuable or not. Perceived difficult subjects or topics (e.g. mathematics) may be circumvented in favour of subjects considered as easier.

2.1.4 Guidance and counselling based educational methods

This enables students to carry out learning to acquire knowledge, experiences, and skills according to their choice of career path. The advantages and disadvantages of this manner can be described as follows (Crawford et al, 1998):

One of the advantages is that tutors with appropriate experience can suggest learning materials to learners that match their personal focus. Also, tutors can specify material that is more demanding, difficult, and potentially less engaging but that is motivating as it will be valuable for learners in their future careers. One of the disadvantages is that learners themselves may not have the ability to design suitable learning plans because of their lack of experience. For example, a student allows insufficient time for a topic. Furthermore, learners do not have the right to select learning material according to their personal interests.

2.1.5 Self-pace teaching and learning style

Self-paced teaching (Mithaug, 2003) is an instructional mechanism that allows learners to take charge of all items in their learning without assistance from staff. The advantages and disadvantages of the self-paced approach can be described as follows (Pollack, 2005):

An advantage of this method is that learners can plan and manage their learning relative to their personal objectives e.g. they can select specific learning content. In addition, learners can get a lot of experience in how to acquire the required knowledge and skills by themselves. A disadvantage to this style is that it omits staff advice to students, which should ordinarily assist students in making appropriate decisions. Moreover, this method asks learners to develop a deep individual understanding of their course which may be difficult for some students.

2.1.6 Guided discovery pedagogy approach

Guided discovery (Elsom-Cook, 1990) is an interactive teaching and learning method in which tutors design some process to achieve particular aims. The locus of pedagogical control is with the student who in the context of a rich environment looks to discover new knowledge to build upon their existing mental models. The guided approach but open method is enhanced by some careful coaching. Learners are encouraged to build varieties of reasoning processes with different knowledge domains to achieve their personalized tasks under the guidance of Artificial Intelligence tutors. The advantages and disadvantages of this method can be described as follows (Wong, 1992):

One of the advantages of this style is that students' individual creativity can be encouraged. In addition, this style can enhance students' concept of self - that is an ability to organize and interpret their inner world of personal existence. A positive self-concept is helpful for learners to develop a positive attitude to learning. Furthermore, staff may rapidly identify the learning abilities of cohorts of students and divide them into a few groups with the similar approaches, which can improve teaching and learning efficiency. One of the disadvantages of this method is that learners may take a long time to achieve the learning objectives. Also, tutors take more time to develop personalized learning processes and materials. This approach can require more feedback to students so they can complete their educational aims.

2.1.7 Inquiry Based Learning

Inquiry based learning (Vygotsky, 1934; Bruner, 1961; CILASS, 2009; Gordon and Brayshaw, 2010) allows users to learn in a self-paced user driven fashion, asking questions about the world, and to build upon their existing knowledge to develop new knowledge found through the course of inquiry. Experts may ask

questions in a different language to novices but all are capable of inquiry within the context of expertise they inhabit.

An advantage with this type of learning is that is emphasises the links between research and teaching – the so called research-teaching nexus. Furthermore, it offers opportunities to engage students as they carry out research and are finding out new facts or ideas. A disadvantage of this approach is the difficulty of managing the process, and of ensuring that the desired learning outcomes are achieved. Where the learning outcomes are process based, this is not a problem, but it raises issues regarding content focussed learning outcomes.

2.1.8 Blended learning

The mixed use within a single system of several teaching and learning styles can offer a mix of the benefits identified so far. For example, self paced, collaborative, and inquiry based teaching styles could all be used together in one form of blend (Allen, 2007; Leung et al, 2008). In the context of teaching and learning programming Choy et al (2007) demonstrated PASS, a system that provides step-wise refinement in a blended context. Here, the range of style of educational paradigm is wide. In the next section we aim to expand the space of choices by not limiting our range to didactic paradigms but also consider personalized choices. Based upon an individual's past learning and current circumstances, we can reflect these in the choices we make available to the learner.

2.2 Personalized Creation of Educational Processes

A teaching and learning journey is a means for students to obtain knowledge, experiences and skills (Huitt, 2003). Such a journey should take account of the differences in the actual requirements of learners and tutors in education e.g. their goals, knowledge background and results. Furthermore, as users of a system, the possible behaviours of learners in building instructional processes are individual and changeable (Hawryszkiewycz, 2000). Here we review some of the main demands of pedagogy styles from the point of view of designing and authoring learning processes. Generally these demands can be classified into two types: common and individual, which we now explore.

2.2.1 Common teaching and learning process

This is a type of educational method that focuses on the general requirements of students (Nicholls, 1999). In this approach, students and tutors may cooperatively decide on common learning resources. The advantages and disadvantages of the common process may be described as follows (Hart, 1993): one of the advantages of this method is that it allows staff to teach groups of learners with common demands at the same time. If a majority of students lack similar knowledge in an area, the tutor may adopt this method to teach them. It means that tutors and learners may save time and resource. Moreover, this approach could develop knowledge in students in a systematic and collective way. One problem with this method is that it limits the freedom for learners in their learning experience. Specifically, students have to study the specific content selected by tutors, even if these materials are not suitable for their demands. Furthermore, the processes are designed to be generic so learners cannot aggregate the content in terms of their personalized requirements. That is, this type of teaching and learning process focuses on the mutual requirements of students and omits their individuality. So this approach cannot provide for learner's specific individual requirements.

2.2.2 Individual teaching and learning process

With a focus on the personal needs of students (O'Brien and Guiney, 2001), the advantages and disadvantages of the individual teaching and learning process may be described as follows (Ackerman et al, 1999). The main advantage of this method is that it can provide the flexibility for tutors and students to establish their own personalized educational process. It is designed mainly for the individual learner and does not attempt to address common issues. In detail, students may import their preferred learning units into the learning process. As different learners have different learning abilities, this method can provide learning units suitable to the different abilities of individual students. Furthermore, the teaching and learning schedules may be personalized to meet various requirements of the learners and tutors. Moreover, students may design the relationships among the indicated learning units in terms of their personalized needs. It means that learners can directly attend exams without completing the learning content that precedes the test. If they do not pass the exams, they may return to learn this content. Finally, the various demands of employers in knowledge, experiences, and skills could be added into personalized teaching and learning processes. This could assist students in getting their preferred jobs. The main drawback of this method is that it could be very difficult to implement. Every learner may have a number of requirements. Furthermore, the non-electronic resources (e.g. books, journals, and classrooms) in an institution could be limited, which make it difficult to meet the individual needs of learners. In addition, staff constraints may mean they cannot support the students. The workload to support all kinds of personalized teaching and learning processes could be too large for tutors in

institutions. So existing educational organizations can only provide restricted support for individual teaching and learning processes. One potential way to deal with this could be by using computer technologies.

It has been argued elsewhere (Brayshaw, 1993a & b) that the goals and requirements of potential information provision is vast and no single solution will always be the best - the solution to support these exceptional users was to "roll their own" system. Here we attempt to do the same thing but in the context of management of education resources described in terms of semantic web resources. In order to do this we are going to describe the personalized control of teaching and learning processes via a method that supports the intelligent management of instructional procedures and units during their execution (Ayers, 1993). The aim of this control is to support the new requirements of users (Tait and Mills, 1999). However in doing so it is also a requirement to have some control and restrictions within the system. The incremental nature of learning means sometimes there is a required ordering between units and appropriate pre-requisites will need to be managed within the system.

2.3 Methodology

In order to gauge the effectiveness of both the approach and implementation an evaluation study was carried out using material on learning a programming language (see Wen, 2008). An example of a traditional approach to this is to have a systematic comparison of the first 20 hours of learning a computer language (e.g. Anderson et al, 1984). However, such approaches centre on comparing like with like, so that there are set axis, for example curriculum, order of presentation of material, structure of material, underlying underpinnings and rationale for such choices. The whole point of personalisation is that one can be free from these straight-jacket approaches. An individual is free to have their own voyage and this may be a very different first 20 hours to the next person. Indeed the very nature of Web-Based Learning means that comparing the experience with the, "…person sitting next to them…" in a traditional lab based scenario no longer makes any sense. Who know the circumstances of an individual's learning, their whereabouts, background (including education), equipment, connectivity, goals or capacity? So an evaluation based on the experience of an individual learner, whilst very valuable is therefore very hard to do.

An alternative approach is used to evaluate the framework described below, that gets around this problem by adopting a different methodology. Alternative authoritative voices to evaluate the effectiveness of the proposed solution are experts in that field – and particularly ones who concern themselves with the professional delivery of the same services proposed by the software under evaluation. Heuristic Evaluation (Nielson and Molich, 1990; Nielsen and Mack, 1994; Nielsen, 2005) has been developed as a technique that provides a framework for experts to evaluate a software system. The heuristics provide a set of axis on which to evaluate the effectiveness of the software under scrutiny. Squires and Preece (1999) extended these heuristics for use in the educational content. Benson et al (2001) further used experts as heuristic evaluators of the educational effectiveness of software, and it is the approach that was adopted to assess the system below (see Wen (2008) for details of the evaluation).

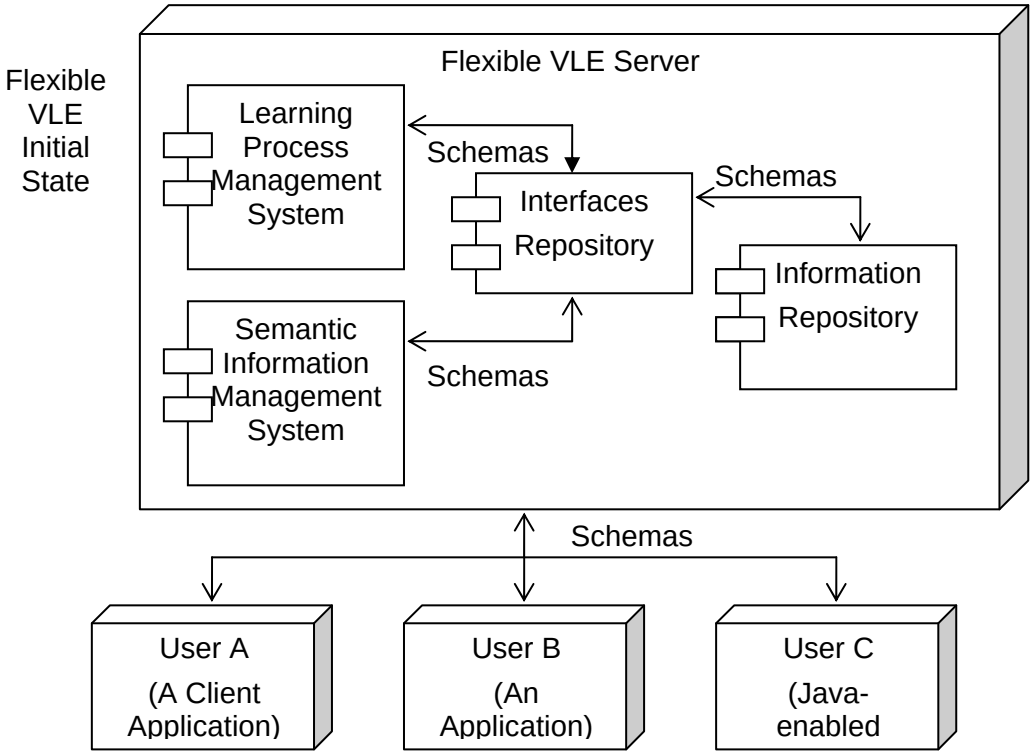

Figure 1. The UML component diagram of the initial state of a flexible virtual learning environment.

2.4 Managing Learning Resources - Technical Issues with Learning Objects, Repositories and Searching the Semantic Web

Whilst the focus of this paper is the way in which resources are presented and managed by learners, it is necessary to consider some related issues that affect the practicalities of using such a system. The first issue is that of how learning material is presented and packaged, in the context of eLearning systems. A variety of standards exist to assist in the packaging of material, such as LAMS (Dalziel, 2006) and LOM-Core (Zope, 2008). Other approaches to learning objects focus on providing reusable material, in the form of reusable learning objects. The issue of locating and selecting these is still non-trivial, but the development of effective search engines utilising the semantic web, along with standard sets of meta-data to describe learning materials (Gordon & Brayshaw, 2009) offer mechanisms to support this part of the teaching process. Supporting the wide range of learning styles identified above means that being able to locate and source collections of learning content (such as reusable learning objects, or more customisable content based on generic patterns) could be supported by an add-on tool to allow effective searching of the semantic web for such materials.

2.4.1 A Personalized E-Learning System

In this section, we describe the design of a personalized virtual learning environment by aggregating various computer technologies and methods (Wen and Jesshope, 2003, 2004), which could support users to design, perform, and manage their own personalized instructional procedures within their personal preferred pedagogy styles. This system is presented in two layers: model and architecture which give the representation of system components from the high level to the low level.

2.4.2 A Model of Personalized E-Learning Systems

Here we present a model to represent the two states of a personalized virtual learning environment, which is Web-based and established on the client/server infrastructure. This model is designed based on widely-used standards such as UK LOM Core (JISC, 2002) and IMS Learning Design (Dalziel, 2006). The main feature of this model is that it describes the procedure of the transformation of a flexible virtual learning environment from initial state to a running environment by using UML (Flint et al, 2004). The initial state (Figure 1) presents the basic configuration of this system. Also the running environment (Figure 2) shows the class and package model of the system. In summary, according to users' requirements, the system components will be allocated to users on the Web (Wen and Jesshope, 2003).The proposed system then enters into the running environment in which users do their teaching and learning.

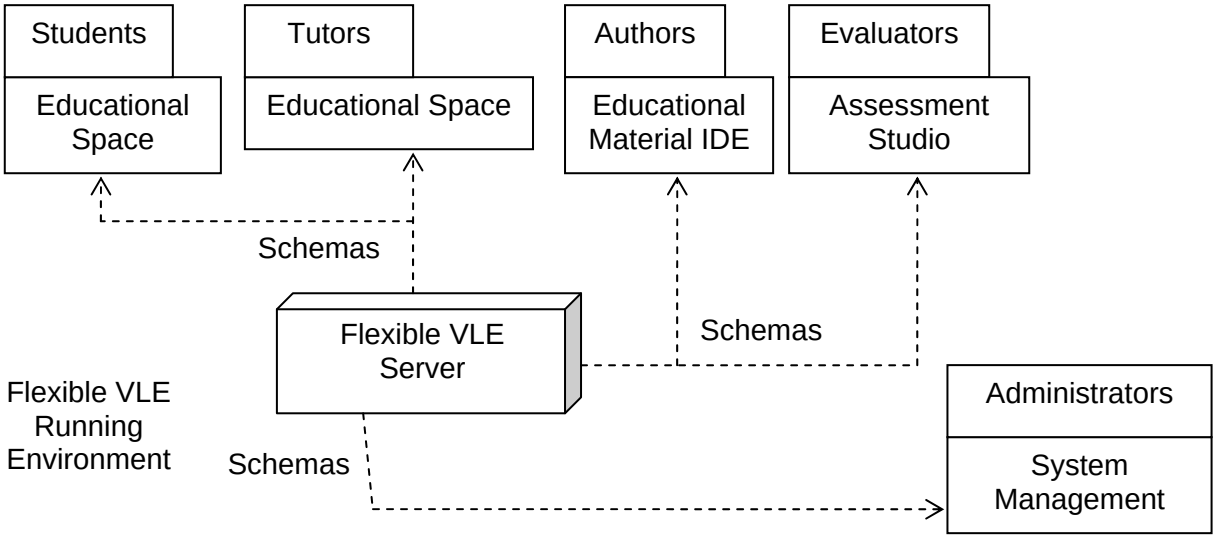

Figure 2. The UML package diagram of the running state of flexible virtual learning environments

The Learning Process Management System is a collection of applications to support the flexible management of learning units and processes. According to users' demands, this system could build and control personalized learning processes through assembling learning units based on their semantic information. *The Semantic Information Management System* is a repository of applications to be responsible for the management of databases of schemas, ontologies, and data elements. This system is designed based on the schema-driven distributed database management system. *The Interfaces Repository* contains a set of interfaces such as user interfaces and APIs, which could support the interaction between users and this model and among the components of the model. *The Information Repository* is a collection of the databases of schemas, ontologies, and metadata. Every database is mainly composed of four types of tables: schema table, vocabulary table, term table, and relationship table. For details of these items see Wen (2008). According to the roles in this system, the related components are allocated to students, tutors, authors, evaluators, and administrators, which are shown in Figure 2.

The Educational space is an interesting and powerful teaching and learning environment, which provides the functions for users to intelligently control their instructional processes and units by using a learning process management system. *The Educational Material IDE* refers to the software that supports authors to create personalized schemas and terms based on a learning process management system and a semantic information management system. *Assessment Studio* is a system for evaluators to assess the learning results of learners by using a learning process management system. Next based on the assessment, tutors who may also be evaluators may control the procedures of learners. *System Management* consists of a set of applications that can be used to maintain, update, and manage a flexible virtual learning environment by system administrators.

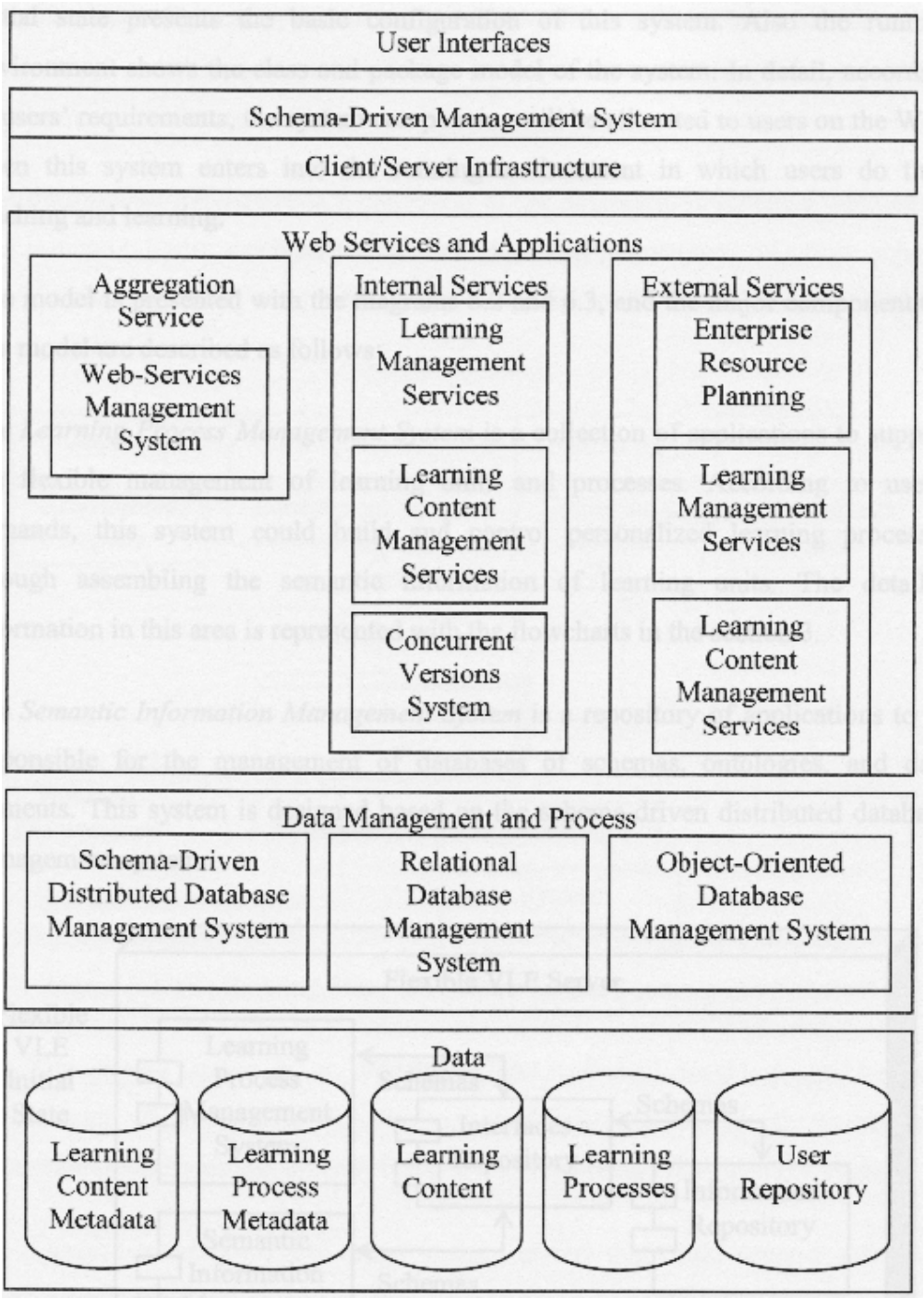

Figure 3: The Framework for the Flexible Learning Environment

2.4.3 An Architecture of Personalized E-Learning Systems

In this section, architecture for an intelligent virtual learning environment is presented to readers, which takes charge of creating and controlling varieties of instructional processes based on users' personalized requirements at the pedagogy level. The main components can be described as follows:

- *Determine Pedagogy Styles and Aims* as previously discussed
- *The Schema Processor* (Wen and Jessope, 2004) is an intelligent mechanism that is responsible for the implementation of personalized operations to units and processes. In a schema processor, an application is used to capture the requirements input by users and automatically aggregates the semantic information (e.g. orders and conditions) of learning units to create the users' personal educational procedures. *Select Learning Units* - a semantic-based method that can support users to

get their desired learning content on the Internet. In this system learning units may be identified locally or via any URL.

Figure 3 shows a working environment for this flexible e-learning system controlled by the schema-driven approach (see also Wen and Brayshaw, 2010). Some building blocks of this system have been discussed before such as the schema driven management system. Other components are described as follows:

- *The Client/Server Infrastructure* is a platform on which applications and servers are performed and represents the backbone of the implemented system.
- *The Web Services and Applications Layer* is a collection of services and applications e.g. Enterprise Resource Planning (ERP) can support various business processes to provide the services required by customers (Basu & Lederer, 2004).
- *The Data Layer* contains a set of databases such as the database to store schemas, ontologies, and metadata in the e-learning area, as well as the real learning material.

2.4.4 Prototype Implementation

This paper presents a prototype implementation to address the practicalities of style and content personalization for web based learning. The software was built using JBuilder9 (Borland, 2006), SQL, and XML. The system allowed flexibility in assembling schema-driven learning process. After first agreeing individual teaching and learning styles and objectives, the user could then choose the learning objects to taste.

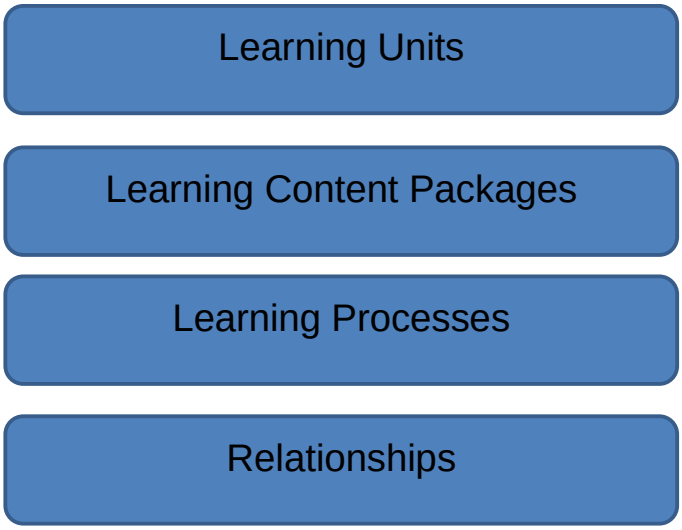

Figure 4. Menu for users to manage the basic databases, access the individual Learning Units and then set up of the synthesised new curricula, via Learning Processes. Specific relationships between units can be affected using the relationship tag.

An example set of learning units is shown in Figure 5. Notwithstanding the teaching and learning style the notion of a “lock” was introduced so that an instructor could insist on pre-requisite units being passed first. Whilst the system would support highly open user centred choice, if the tutor felt that an advanced unit should only be attempted once an introductory unit had been satisfactorily passed, that advanced unit could be locked, and only unlocked for student selection if the introductory unit requirements were satisfied.

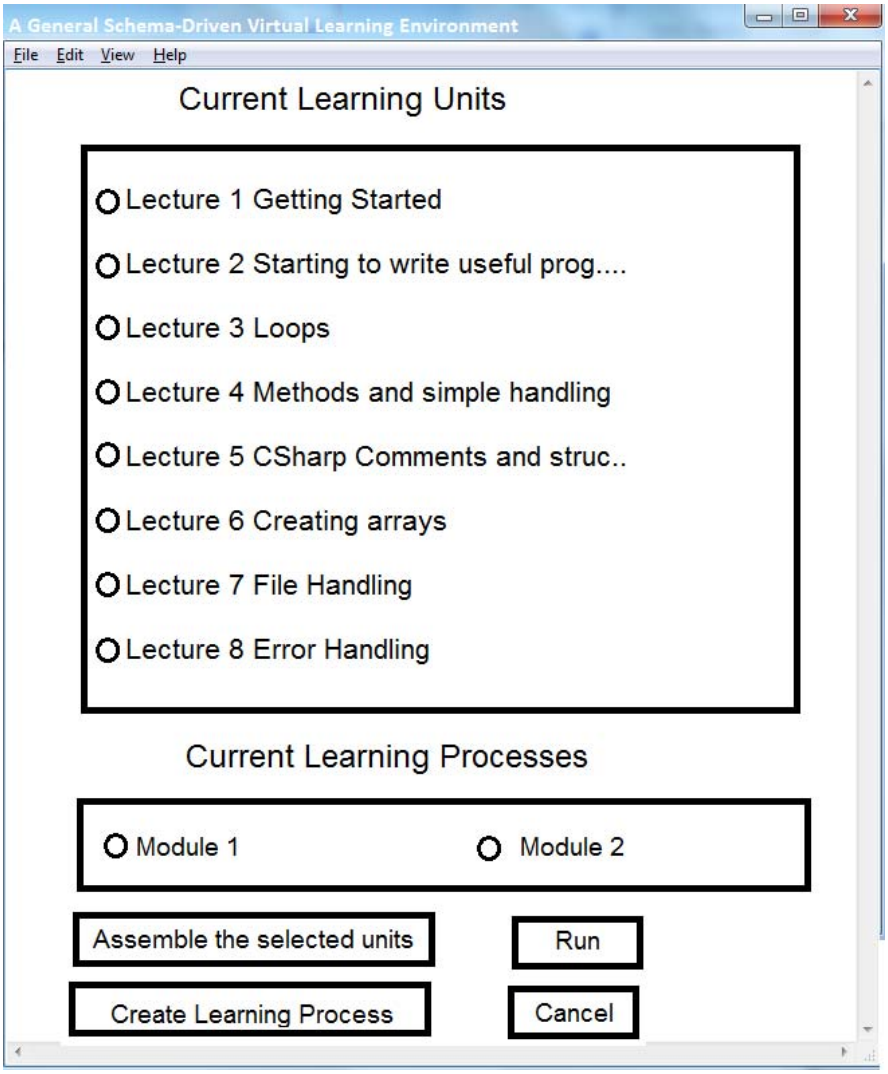

Figure 5. A Selection of Learning Objects for the Data Management Layer.

Assemble Learning Units in Figure 5 will assemble the units according to teaching and learning style. Once these have been done this can then be made into a curriculum using the *Create Learning Process* as shown in Figure 6.

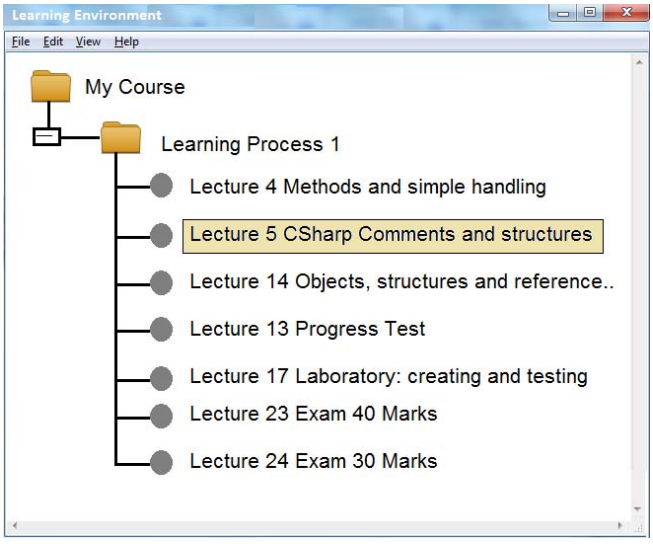

Figure 6. A Personalized Construction of a Learning Process.

2.5 Conclusions and Future Work

Is the concept of a learning object still as relevant in the age of Web 2.0 and the Semantic Web and if so what is their optimized size?. Typically, learning objects are considered as small units of learning, whereas the larger learning objects that we use in the study here have the advantages that it makes aggregation easer. That they are substantial collections of material that may indeed be the complete treatment of a particular topic means that moving them about is fairly easy to do. This however means that fine tuning for a particular teaching and learning style is harder. Take for example a behaviour based approach; this would favour smaller steps with a tight emphasis on feedback provided. Further in the age of mashups and the more dynamic assembly of material, splitting our learning objects up into finer items is the next step in this work. The system and the way it works and indexes would be the same the only change that would be needed is one of the granularity of the learning materials.

The research refined the practical demands of learners and staff at the layer of pedagogy. Next the detailed designing of personalized virtual learning environments was presented. Through analysing the functionality of this system, we have shown the potential to support the intelligent design and control of personalized performance in e-learning Web services and applications. Furthermore, the system can build a range of teaching and learning styles on the Web. Whilst this demonstrates a functional prototype of a personalized virtual learning environment, the next step could be importing the tool into a practical learning environment. The tool would face an actual inspection and evaluation based on use, which may lead to further refinement of the tool.

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