The use of tagging to support the authoring of personalisable learning content

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ABSTRACT

This research project is interested in the area of personalised and adaptable learning and in particular within an e-learning context. Brusilovsky (1996) and Santally (2005) stress the importance of adaptive systems within e-learning. Karagiannikis and Sampson et al. (2004) argue that personalised learning systems can be defined by their capability to adapt automatically to the changing attitudes of the "learning experience" which can, in turn, be defined by the individual learner characteristics, for example the type of learning material.

The project evolved to cover areas including personalised learning, e-learning environments, authoring tools, tagging, learning objects, learning theories and learning styles. The main focus at the start of the project was to provide a personalised and adaptable learning environment for students based on their learning style. During the research, this led to a specific interest about how an academic can create, tag and author learning objects to provide the capability of personalised adaptable e-learning for a learner.

Research undertaken was designed to gain an understanding of personalised and adaptive learning techniques, e-learning tools and learning styles. Important findings of this research showed that e-learning platforms do not offer much in the way of a personalised learning experience for a learner. Additionally, the research showed that general adaptive systems and adaptive systems incorporating learning styles are not commonly used or available due to issues with flexibility, reuse and integration.

The concept of tagging was investigated during the research and it was found that tagging is underused within e-learning, although the research shows that it could be a good 'fit' within e-learning. This therefore led to the decision to create a general-purpose discriminatory tagging methodology to allow authors to tag learning objects for personalisation and reuse. The main focus for the evaluation of this tagging methodology was the authoring side of the tagging. It was found that other research projects have evaluated the personalisation of learning content based on a learner's learning style (see Graf and Kinshuk (2007)). It was therefore felt that there was a

sufficient body of existing evidence in this area whereas there was limited research available on the authoring side.

The evaluation of the discriminatory tagging methodology demonstrated that the methodology could allow for any discrimination between learners to be used. The example demonstrated within this thesis includes discriminating according to a learner's learning style and accessibility type. This type of platform independent flexible discriminatory methodology does not exist within current e-learning platforms or other e-learning systems. Therefore, the main contribution of this thesis is therefore a platform independent general-purpose discriminatory tagging methodology.

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1 Introduction

1.1 Rationale

Much research has been undertaken about how we learn and how a learner's learning style affects this learning process. From the behaviourist approach of Skinner (1974) and Watson (1930) to the constructivist approach of Vygotsky (1978) and Piaget (1973) there has been an on-going debate about how to develop instructional design theory, in order to provide a much richer learning environment for learners. Some of the research within this field shows we are far from being able to pass a unanimous judgement on both technical and pedagogical aspects of e-learning in general, and personalised e-learning in particular.

Personalisation of e-learning is viewed by many authors (see amongst others Eklund and Brusilovsky (1998), Kurzel, Slay and Hagenus (2003), Martinez (2000), Sampson, Karagiannidis and Kinshuk (2002) and Voigt and Swatman (2003)) as the key challenge for the learning technologists. According to Kurzel (2004) the tailoring of e-learning applications can have an impact on content and how it's accessed; the media forms used; method of instruction employed and the learning styles supported.

The word "personalisation" is used widely. However, it is felt that this term often refers to a fairly limited understanding of the concept. It is thought that people often think that personalisation on the web is similar to a scenario such as Amazon, which remembers the user, their particular buying pattern and behaviour and offers them a "personalised" page. Often personalisation like this can be little more than tracking the users' shopping habits using cookies to store this information. However the question is how can e-learning be individually 'customised' or 'personalised' on a mass scale? Issues here are that there is still an on-going debate about what 'personalisation' actually means and also that there is no set of 'standards' available for guidance. The mass system i.e. where one educational approach is delivered to all students, may work for the majority, but the minority are failed by it, so the use of personalisation of learning is seen as a means to improve the failing performance of the minority by addressing their needs directly, within the mass system, and potentially achieving an overall improvement for all students.

Furthermore, the current state of digital content available for e-learning indicates a wide variety of formats, platforms and subject areas are in use with very little, if any, interoperability.

Learning styles and how we learn is a vast research area. Brusilovsky and Millán (2007) argue that learning styles are typically defined as the way people prefer to learn. The concept and validity of learning styles are a hotly debated topic, however, that aside; many research projects incorporate learning styles into their adaptive e-learning systems (for example Graf and Kinshuk (2007)). These systems are not widely used today and one reason for this is that the functionality offered is inflexible.

In considering the problem of the common e-learning systems that generally provide a 'one size fits all' model, this research is interested in looking at the area of personalised learning and to investigate the ability to offer personalised learning according to a learner's learning style.

1.2 Initial hypothesis

The initial research hypothesis is as follows:

"A mechanism can be developed to personalise learning materials to an individual learner according to their learning style".

1.3 Aims and objectives

The hypothesis will be the basis for this research and the aims of this research project are as follows:

- To understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles.

- To develop a unique approach that supports the personalisation of learning materials and the use of learning styles.

In order to achieve these aims, the following research objectives have been identified:

- To carry out a critical and comprehensive review of research within the area of e-learning tools, personalised and adaptive learning, and learning styles.
- To investigate current trends and technologies within e-learning.
- To create and evaluate a model to offer personalised learning based on a learner's learning style.

1.4 Structure of thesis

The structure of this thesis is as follows:

Chapter 2 gives an overview of teaching and learning theories and how these relate to e-learning and learning design. Specifically, the learning theories described are behaviourism, cognitivism and constructivism and the learning approaches described are pedagogy, andragogy and heutagogy. This chapter describes these theories and approaches and looks at any benefits and criticisms.

This chapter also describes learning styles and how they have been both promoted and criticised by researchers. It describes current research and categorization of learning styles and learning styles that are used within adaptive e-learning environments. It then goes on to describe a selection of common learning styles in detail and some criticisms of learning styles.

The author published the learning style research described within this chapter in a paper in 2008. The title of the paper was "Evaluation of a suitable learning style for iLearn: a personalised e-learning platform" and contained the evaluation of learning styles for personalisation and adaptability (see Peter et al. (2008)).

Chapter 3 describes and evaluates the different types of authoring tools that are available. These include general authoring tools e.g. HTML pro (2008), e-learning platforms (e.g. Moodle) and adaptive web based educational systems. Additionally, this chapter goes on to describe adaptive systems that incorporate learning styles e.g. INSPIRE (Grigoriadou et al (2001)).

Additionally this chapter also describes personalised and adaptive learning and then specifically looks at e-learning platforms. The chapter evaluates how much personalised and adaptive learning current e-learning platforms provide. The author published the e-learning platform research described within this chapter in a paper in 2009. The title of the paper was "evaluating the personalised and adaptable learning provided by e-learning platforms" (see Peter et al. (2009)).

This chapter also discusses tagging objects and standards within e-learning systems. Specifically it describes learning and assessment objects, standards and to what extent they are currently being tagged within e-learning systems. This metadata research is discussed within a paper published by the author in 2010. The title of the paper is "Designing metadata for learning and assessment objects" (see Peter et. al. (2010)). The tagging section from this thesis is also part of a published paper published by the author in 2011. The title of this paper is "Tagging learning objects in Moodle for personalisation and reuse" (see Peter et al. (2011)).

Chapter 4 describes the design of a tagging model for learning object personalisation and reuse. It gives an overview of the tagging model, learning material tagging and metadata design, learning style representation, learner profile and the personalised learning package. The initial metadata tagging model design was published within a paper published by the author in 2010. The title of the paper is "Designing metadata for learning and assessment objects" (see Peter et al. (2010)).

Chapter 5 describes the implementation of a prototype, which is an extension of Moodle incorporating tagging for personalisation and reuse. Moodle is a tool that has leant itself to this implementation, however, this model can be developed in other environments and platforms as necessary. This chapter describes Moodle as a development tool, and the enhanced functionality for both authoring and searching learning objects. The author published the initial instructor tagging implementation in 2011. The title of this paper is "Tagging learning objects in Moodle for personalisation and reuse" (see Peter et al. (2011)).

Chapter 6 describes the experimental design. It describes the studies that have been devised to test and evaluate the model and the prototype. Different parts of the model and prototype are tested, and these studies consist of a critical reflection, walkthroughs, questionnaires and unstructured interviews. The studies are described in detail in this chapter.

Chapter 7 describes the results and analysis of the research. Results for a number of studies are described, including studies undertaken by expert evaluators.

Chapter 8 provides an overall conclusion to the research project with recommendations and also describes how the work could be taken forward.

2 Learning theories and learning styles

2.1 Introduction

Many research studies have been conducted about how we learn and how learners learning style affects the learning process. The research undertaken within this chapter is intended to address the research aim “to understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles”.

As the hypothesis for the research is “a mechanism can be developed to personalise learning materials to an individual learner according to their learning style”, the overall purpose of the research described in this chapter is to evaluate learning theories and approaches to see how they ‘fit’ with personalised learning environments and to investigate learning styles and evaluate them for their suitability to use within a personalised and adaptive learning style environment.

At the beginning of this chapter, the theories of learning and teaching and learning approaches will be discussed in detail. The main theories of learning explained are behaviourism, cognitivism and constructivism and the main learning approaches considered are pedagogy, andragogy and heutagogy.

In particular, this research will look at the differences between these theories and approaches of learning and discuss any criticisms or benefits of using them. This research will investigate which theory or approach will be the best fit to enable personalised and adaptive learning.

Learning styles and how we learn is a large research area and this will also be discussed within this chapter. Many learning styles, for example Kolb (Kolb, 1976) and Dunn and Dunn learning style model (Dunn and Dunn, 1974) have been developed and this chapter describes these common learning styles in detail including how they are categorised and measured. Many educationalists and researchers have criticised learning styles over the years, and these criticisms of learning styles will also be discussed.

Finally this chapter investigates learning styles further and in particular evaluates learning styles for their suitability for use within a personalised adaptive learning environment. Specifically, some common learning styles are evaluated with a criterion to see how well their categories would be able to be mapped to learning objects within a personalised learning environment. The evaluation tools for these learning styles will also be assessed.

Within the conclusion of this chapter the project hypothesis, aims and objectives will be revisited to see whether they have changed or have been satisfied by the research undertaken.

2.2 Theories and approaches of learning

2.2.1 Learning theories

Three important learning theories have had a major impact in learning and instructional design and these are behaviourism, cognitivism and constructivism. Additionally, there is an on-going debate about how to develop instructional design theory in order to provide a much richer learning environment for learners.

The three theories of behaviourism, cognitivism and constructivism will be discussed in further detail within the next section of this chapter.

2.2.1.1 Behaviourism theory

The behaviourism approach (Pavlov (1927), Skinner (1974) and Watson (1930) amongst others) sees the mind as a "black box" that responds to a stimulus.

Skinner (1974) states "learning is a chance in observable behaviour caused by external stimuli in an environment". Skinner (1974) also argues that behaviourism ignores any consideration of the thought process that may occur in the mind. Behaviourism's focus is to observe any changes in behaviour and whether a new behavioural pattern is being repeated until it becomes automatic. Therefore, behaviourism deals with studying learner behaviours that can be observed and measured.

Watson (1930) defined learning as "a sequence of stimulus and response to actions in observable cause and effect relationships". Furthermore, Forrester (2002) states that the behaviourists' example of conditioning demonstrates the process where a human learns to respond to neutral stimuli in a way that would normally be associated with unconditioned stimuli.

There are a number of known experiments demonstrating the conditioning behaviourism theory. One of the most well known experiments is the Pavlov's dog behaviourism experiment. According to Forrester (2002) this experiment focused on the digestive process in animals. When conducting the experiment, Pavlov found that the dog would salivate (a response) when hearing a bell. This experiment showed that this occurred because the dog had started to associate feeding with the bell ringing. Watson (1930) therefore believed that humans might similarly react to stimuli generated internally (for example hunger) or externally (for example a loud noise).

Forrester (2002) also states that Skinner expanded this further by focusing on human behaviour and he proposed that voluntary or automatic behaviour is either strengthened or weakened by the immediate presence of a reward or punishment.

As far as e-learning and behaviourism is concerned, Modritscher (2006) highlights that Atkins (1993) gives four aspects relevant for realising online courses with respect to the behaviourist school:

- That the learning material should be broken down into instructional steps where possible.

- That course designers have to define sequences of instructions for the learner using either conditional or unconditional branching.
- That some learners may be routed to miss or repeat sections to maximize learning efficiency.
- To allow for the demonstration of an operation, procedure or skill and break it into parts.

Additionally, Modritscher (2006) suggested that overall behaviourists recommend a structured and deductive approach when designing an online course. He states that this will therefore ensure that the learner can rapidly acquire basic concepts, skills and factual information.

It has been found that limitations of this approach come from the actual understanding of learning. Alonso et al. (2004) state that the limitation is that people could imitate any behaviour that they had not reinforced. Bandura (1977) also states that the individual could model their behaviour by observing the behaviour of another person.

Behaviourism's focus therefore is to observe any changes in behaviour when learning and so therefore, behaviourism deals with studying learner behaviours that can be observed and measured. The limitations of this approach are that the learner could imitate behaviour or could copy another learner's behaviour.

2.2.1.2 Cognitivism theory

The cognitivism theory emerged as a response to the behaviourist theory and it's limitations. There is no one agreed definition of cognitivism but generally it is thought that cognitivism theory deals with the thought process the student undertakes when learning. Many authors have made contributions to the debate about cognitivism and they are described within this section.

Ally (2004) argues that this approach "sees learning as an internal process that involves memory, thinking, reflection, abstraction, motivation and meta-cognition". Ally (2004) also suggests that cognitive psychology is interested in the information processing and memory used when learning.

Furthermore, Thompson et al. (1996) argue that the cognitive theory concentrates on the conceptualisation of a student's learning processes and so therefore they maintain that cognitivism focuses on the way information is received, organised, retained and used by the brain.

Sampson and Karagiannidis (2002) suggest that the foundation of cognitive theories argue for active involvement by learners, emphasis on structure and organisation of knowledge, and adding new knowledge to the learner's existing cognitive structures.

Modritscher (2006) promotes that the cognitive school of thought, which recognises the importance of individual differences and of including a variety of learning strategies to accommodate those differences. He also suggests that cognitive psychology focuses on learners' receiving and processing of information to transfer it into long-term memory for storage. He therefore argues that if instructional designers wish to design for the cognitive focused approach then they need to consider:

- Putting learning content into small groups
- Supporting different learning styles up to higher concepts such as motivation, collaboration or metacognition.

Additionally, Modritscher (2006) states that although the cognitive-focused approached is suitable for learners who want to reach higher-level objectives, he argues that there is a major weakness if a learner does not have the relevant pre-requisite knowledge as the content would not be suitable for them.

Alonso et al. (2004) argue that the influence of cognitive science on instructional design is evidenced by the use of advanced learning material organisers, metaphors, chunking the instructional material into meaningful parts and the careful organisation of instructional materials from simple to complex.

This research has shown that the cognitivism theory was developed in response to the behaviourst theory and that it is interested in the memory and information processing used by the learner when learning. The work also demonstrates that instructional designers should consider a number of techniques when designing for this theory, including putting the content into small chunks and giving careful consideration with the organisation of the material.

2.2.1.3 Constructivism theory

Within the contructivism approach (Dewey (1916), Bruner (1986), Montessori (1914), Piaget (1973) and Vygotsky (1978) amongst others), learners interact with the environment and then construct their own knowledge based on that interaction. Forrester (2002) states that constructivists believe all humans have the ability to construct knowledge in their own minds through a process of discovery and problem solving.

Furthermore, Alonso et al. (2004) suggest that constructivism builds upon both behaviourism and cognitivism in the sense that it accepts multiple perspectives and maintains that learning is a personal interpretation of the world. They argue that the constructivist theory maintains that learners construct or interpret their own learning based upon their own experiences.

Forrester et al. (2002) explains how Piaget (1973) observed human development as progressive states of cognitive development. He describes how his four stages, which commence at infancy and progress into adulthood, characterise the cognitive abilities necessary at each stage to construct meaning of ones environment.

Within the constructivist approach, the emphasis is on the learner rather than the teacher. With this in mind, Applefield et al. (2000) state that "constructivism is an epistemological view of knowledge acquisition emphasising knowledge construction rather than knowledge transmission and the recording of information conveyed by others". The role of the learner is conceived as one of building and transforming knowledge.

Applefield et al. (2000) therefore propose that pedagogical recommendations based on the constructivist principles of learning are as follows:

- Learners should be encouraged to raise questions, generate hypotheses and test their validity.
- Learners should be challenged by ideas and experiences that generate inner cognitive conflict or disequilibrium.
- Student's errors should be viewed positively.
- Students should engage in reflection through journal writing, drawing, modeling and discussion. Learning occurs through reflective abstraction.
- The learning environment should provide opportunities for dialogue.
- The students should communicate their ideas to others, defend and justify them.
- Students should work with big ideas, across experiences and disciplines.

In addition, they add to this that the overriding goal of constructivism educators is to stimulate thinking in learners that results in meaningful, deeper understanding and transfer of learning to real world contexts. It is therefore desirable that constructivist lessons have a clear content goal designed around an authentic learning task, question or problem.

Sampson and Karagiannidis (2002) state that constructivist theory implies that instructional designers determine which method and strategies will help learner to actively explore topics and advance their thinking. Additionally, Alonso et al. (2004) assert that one of the most useful tools for the constructivist designer is hypertext and hypermedia because it allows for a branched design rather than a linear format of instruction.

Furthermore, Modritscher (2006) state that some examples of constructivist learning can be found within the scope of experimental learning, self-directed learning, context-aware learning and reflective practice. He states that this learning theory has some disadvantages, such as problems in adequately evaluating the learning process, lack of instructional resources to respond to the multitude of student interest.

The research has shown that constructivism builds upon both behaviourism and cognitivism and within this theory the learner construct their own learning based on their own individual experiences. Hypertext and hypermedia has been highlighted as one of the most useful tool for the constructivist designer and they generally lessons for constructivist learners should have a clear content goal design around authentic learning tasks.

2.2.2 Teaching and learning approaches

The main teaching and learning approaches are pedagogy, andragogy and heutagogy. Pedagogy is defined as teacher-centered, andragogy is defined as student-centred and heutagogy is defined as self-determined. These approaches are now described in more detail within the next section of this chapter.

2.2.2.1 Pedagogy approach

According to McAuliffe et al. (2008) pedagogy dates back to the monastic schools of Europe in the Middle Ages. They also suggest that this tradition of pedagogy was adopted and spread to schools throughout Europe and America in the 18th and 19th centuries. Additionally, they state that pedagogy is derived from the Greek word ‘paid’, which means child, and ‘agogos’ which means leading. Furthermore, Knowles (1970) argues that assumptions regarding learning and learners were based on observation of monks in the teaching of simple skills to children.

Pedagogy describes the traditional relationship between a teacher and a learner. Hase and Kenyon (2000) state that it was always the teacher who described what the learner needed to know, and how that knowledge and skills should be taught and within the research of McAuliffe et al. (2008) this is supported.

Additionally, McAuliffe et al. (2008) suggest that pedagogy is a teaching theory rather than a learning theory and is usually based on transmission. They go on to suggest that the pedagogical model is a content model that is concerned with the transmission of information and skills, where the teacher decides in advance what knowledge or skill should be transmitted. Within this model, this information will be arranged in logical unit, which will be transmitted in sequence.

Additionally, according to Coffield et al. (2004), Dewey (1916) states that pedagogy is often dismissed as futile because: 'Nothing has brought pedagogical theory into greater dispute than the belief that it is identified with handing out to teachers recipes and models to be followed in teaching'.

Pedagogy therefore is a traditional teaching approach that is interested in the transmission of information and skills from a teacher to a learner. Criticism of this approach is that this does not allow for any flexibility or consideration of the individual learner's needs. All material will usually be delivered in sequence, without any element of personalisation for the learner.

2.2.2.2 Andragogy approach

In 1970, Knowles proposed a change in the way educational experiences for adults should be designed and suggested an approach called andragogy.

Hase and Kenyon (2000) state that the andragogy approach contrasts quite sharply with the pedagogy approach. Pedagogy is concerned with the teaching of children, whereas they state that andragogy and the principles of adult learning that were derived from it transformed face-to-face teaching and provided a rationale for distance education based on the notion of self-directedness.

Furthermore Hase and Kenyon (2000) highlight that Knowles (1970) defines self-directed learning as “the process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing learning strategies, and evaluating learning outcomes”.

McAuliffe et al. (2008) explain that the term is defined from the Greek words ‘anere’ which means ‘man’ and ‘agogus’ which means leading and this term is used by adult theorists and educators to describe the theory of adult learning. They state that the andragogical model considers the following issues to be addressed in the learning process:

- To allow for the learner to know why something is important to learn
- To show the learner how to direct themselves through the information
- To relate the topic to the learner’s experience

McAuliffe et al. (2008) also state that there is a great deal of debate and criticism of andragogy, particularly when compared to other teaching and learning theories. For example, Hase and Kenyon (2000) argue that since society has rapidly changed and we now live in a highly technical society, learning should be more self-determined.

Andragogy therefore is self-directed learning, which is in contrast to pedagogy which is the transmission of knowledge from a teacher to a student. McAuliffe et al. (2008) suggest that andragogy can be considered an effective application to various learning situations of the maturing adult learner.

2.2.2.3 Heutagogy approach

Hase and Kenyon (2000) state that the concept of truly self-determined learning, called heutagogy, builds on the humanistic theory and approaches to learning described in the 1950s. McAuliffe et al. (2008) state that the term is derived from the Greek word for 'self' and 'leading' and was coined by Hase and Kenyon (2000) in the late 1990's. It attempts to challenge some ideas about teaching and learning that still prevail in teacher centered learning and it is suggested that heutagogy is appropriate to the needs of learners in the 21st century, particularly in the development of individual capacity.

Hase and Kenyon (2000) also state that a heutagogical approach recognises the need to be flexible in the learning where the teacher provides resources but the learner designs the actual course he or she might take by negotiating the learning. They, therefore, state that learners may read around critical issues or questions and determine what is of interest and relevance to them and then negotiate further reading and assessment tasks.

They also state that heutagogical approaches to education and training emphasise: the humanness in human resources; the worth of self; capability; a systems approach that recognises the system environment interface; and learning as opposed to teaching. Hase and Kenyon (2000) go on to suggest that a shift in thinking towards heutagogy will enable the control of learning to shift more appropriately to the learner. Furthermore, they state it will enable a far more creative approach to learning, no matter what the context.

With this in mind, Canning and Callan (2010) undertook a study based on student responses to experience, study and professional development. They consider how students are supported in taking control of their own learning.

They found that students in their study showed that they were on their way to developing a heutagogical approach to learning by demonstrating:

- That they were self-aware.
- That they were able to articulate feelings, experiences and ideas.
- That they engaged in shared discussions with others.
- That they investigated appropriate academic sources in developing their own 'theories' and knowledge.
- That they were confident in their study skills and able to access the facilities of their institution.

Canning and Callan (2010) therefore suggest that this assessment demonstrates that this has given the students a personal heutagogy in which they are able to revisit and continue to build upon.

Heutagogy therefore challenges some ideas about traditional teaching and learning. Hase and Kenyon (2000) suggest that a shift in thinking towards heutagogy will enable the control of learning to shift more appropriately to the learner. They state that this will enable a far more creative approach to learning, no matter what the context.

2.3 Learning styles

2.3.1 Overview of learning styles

Many definitions exist for learning styles, Brusilovsky and Millán (2007) state that "learning styles are typically defined as the way people prefer to learn" and Dunn et al. (1989) define learning styles as "a biologically and developmentally imposed set of personal characteristics that make the same teaching method effective for some and ineffective for others". Both definitions demonstrate that learning styles are classifying learner according to the way they learn.

Learning styles have also been both promoted and criticised by researchers and this section describes the research undertaken into learning styles. In particular, learning styles that are used within adaptive e-learning environments are described in detail. These adaptive systems incorporating learning styles are discussed in more detail in Chapter 3.

Coffield et al. (2004) state that the field of learning styles consists of a wide variety of approaches that stem from different perspectives, which have some underlying similarities and some conceptual overlap.

Keefe (1979) states that learning styles are characteristic, cognitive, affective and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Since this time, there have been many definitions and many conflicting studies about the effectiveness of learning styles. Sampson and Karagiannidis (2002) state that learning styles have been at the centre of controversy for several decades and there is still little agreement about what learning styles really are, however, one major distinction agreed by the majority of learning styles research is the visual, auditory and kinesthetic distinction.

Haapala (2006) states that according to Felder (1997), learning styles may be defined in part by the answers to five questions that are essential in defining the characteristics of the concept "learning style":

1) What type of information the student preferentially perceives.
2) Which modality is sensory information most effectively perceived.
3) Which organisation of information the student is most comfortable with.
4) How the student prefers to process information.
5) How the student progresses toward understanding.

Previous attempts have been made to try to categorise learning styles. Two examples of this are the learning style categorisation proposed by both Curry (1983) and Coffield (2004).

Curry (1983) (see Figure 1) proposes an onion metaphor consisting of three layers as follows:

- The outermost layer is the instruction preference model. These are the environmental, emotional and sociological preferences of a learner.
- The middle layer is the information processing models. This is the process of acquiring and processing information.
- The innermost layer is focusing on the personality traits of a learner.

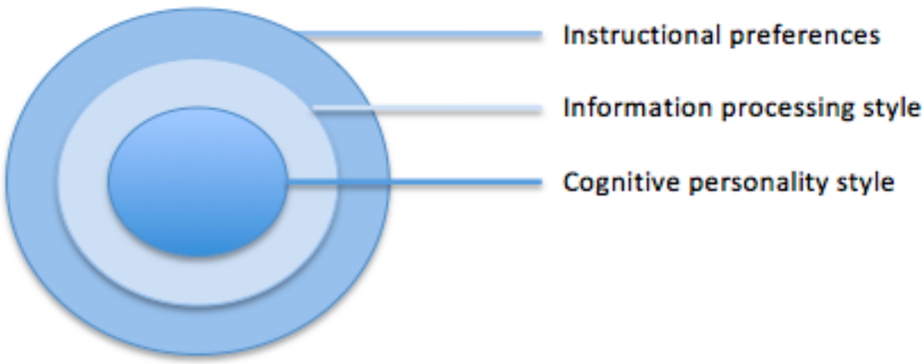


Figure 1: Curry's onion model of learning styles (Curry 1983)

Additionally, to enhance Curry's onion model, Claxton and Murrell (1987) proposed the following fourth layer between Curry's two outer layers:

- The social interaction layer. This layer contains the collaborative aspects that occur during learning.

Coffield et al. (2004) states that although Curry's model has been used as a useful pragmatic way to present different models, they state that however attractive the onion metaphor may be, it is far from clear what actually lies at the centre of the Onion model of learning styles.

With this in mind, Coffield et al. (2004) undertook a very detailed evaluation of learning styles, in which they identified 71 models, 13 of which were categorised into families of learning styles shown in Figure 2.

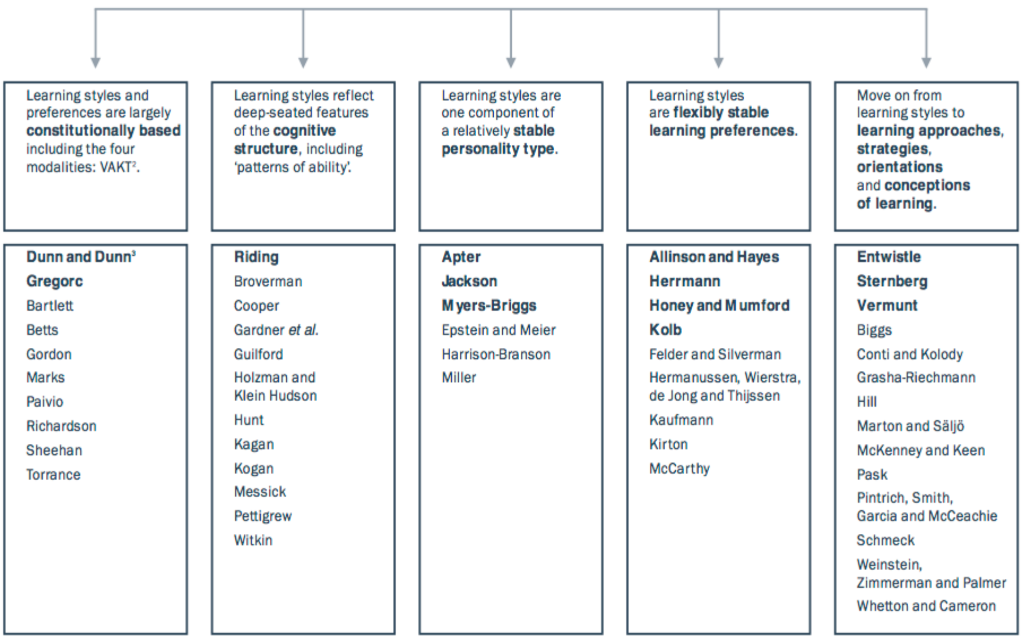


Figure 2: Coffield's family of learning styles

During this research it has been found that a number of learning style models are being used for the purpose of personalisation and adaption within e-learning. These learning styles are Kolb Learning Styles Theory (Kolb, 1985), Felder and Silverman Index of Learning Styles (Felder and Silverman, 1988) and Honey and Mumford Index of Learning Styles (Honey and Mumford, 1992), VARK (Fleming, 2001) and Dunn and Dunn (Dunn and Dunn, 1974). These common learning styles will be described in more detail in the next section of this chapter and Chapter 3 describes the adaptive systems incorporating the learning styles in more detail.

2.3.2 Examples of learning styles used within adaptive systems

2.3.2.1 Kolb Learning Style

Kolb (1976) argues that learning is the process whereby knowledge is created through the transformation of experience. Kolb (1985) also suggests that knowledge results from the combination of grasping experiences and transforming it.

This learning style theory proposed by Kolb (1985) is based on the Experiential Learning Theory and the main styles proposed in this model (summarised in Figure 3) are as follows:

- The converging learner style (abstract, active).
  - This style type includes the learner being good at problem solving and taking decisions. They prefer to deal with technical rather than interpersonal issues.
- The diverging learner style (concrete, reflective).
  - This style type includes being imaginative and aware of meanings and values and views concrete situations from many perspectives.
- The assimilating learner style (abstract, reflective).
  - This style type prefers abstract conceptualisation and reflective observation. They are concerned with ideas and abstract concepts rather than with people.
- The accommodating learner style (concrete, active).
  - This style type likes doing things, carries out plans and gets involved in new experiences. They are good at adapting to change and are at ease with people but can seem impatient.

The model suggests that the learner should cycle through all four styles in order to gain a full understanding of the topic.

The assessment tool for Kolb's theory is the learning style inventory (LSI). The tool offers 12 sentences that describe learning and the learner is asked to rank these to best describe how they learn.

Many studies have evaluated the Kolb's theory and have highlighted issues and weaknesses with the learning style inventory. In particular, Coffield et al. (2004) state that issues have been raised about the scoring method for this tool in particular the test retest reliability. Studies have demonstrated the problem according to Coffield et al. (2004) and they give as an example Ruble and Stout (1992) who found that 56% of their respondents maintained the same learning style, however, at the second test 16% changed to the opposite learning style, e.g. from assimilator to accommodator.

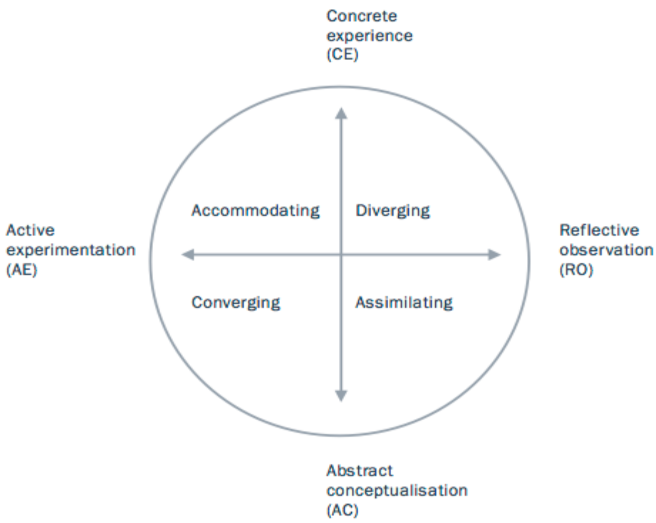


Figure 3: Kolb's four learning styles (figure from Coffield 2004)

2.3.2.2 Honey and Mumford's Learning Styles Model

The learning style model by Honey and Mumford (1992) is based on Kolb's Experiential Learning Theory (Kolb, 1985).

Coffield et al. (2004) state that instead of asking people directly how they learn, as Kolb's Learning Style Indicator does, the Honey and Mumford model provides them with a questionnaire in which it probes general behavioural tendencies rather than asking questions about learning.

According to Honey and Mumford (1992), a learning style is a description of the attitudes and behaviour that determines an individual's preferred way of learning. The learning style categories that they propose are activists, reflectors, theorists and pragmatists. Strengths and weaknesses are defined for each of these learning style categories. However, Honey and Mumford (2000) argue that no single style has an advantage over any other as they state that the strengths and weaknesses of a style may be important in one situation but not another.

Activities and preferences are defined by Honey and Mumford (1992) and they define what the different learning style categories react positively to and they are as follows:

Activists react positively to:

- Action learning, business game simulations, job rotation, discussion in small groups, role playing, training others and outdoor activities.

Reflectors react positively to:

- E-learning, learning reviews, listening to lectures or presentations, observing role plays, reading and self-study/self-directed learning.

Theorists react positively to:

- Analytical reviewing, exercises with a right answer, listening to lectures, self-study/self-directed learning, solo exercises and watching 'talking head' videos.

Pragmatists react positively to

- Action learning, discussion about work, discussion in small groups, group work with tasks where learning is applied.

The measurement tool for this method is the learning styles questionnaire. This tool consists of 80 questions that probe preferences for four learning styles with 20 items for each style.

Coffield et al. (2004) argue that since its development it has attracted considerable interest, application and research. Initially it was welcomed as an improvement on Kolb's Learning Style Indicator, but evaluations have since taken place (e.g. Duff and Duffy, 2002) that criticise the tool casting doubt on the psychometric robustness of the Learning Style Questionnaire and its ability to predict performance.

2.3.2.3 Felder and Silverman index of learning styles

Felder and Silverman (1988) state that "students learn in many ways – by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualising and drawing analogies and building mathematic models; steadily and in fits and starts".

The Index of learning styles model defines a learning style as "the characteristic strengths and preferences in the ways individuals take in and process information" (Felder and Silverman, 1988).

The Felder and Silverman model categorises an individual as:

- Sensing - intuitive
    - Sensor learners prefer facts, data, solving problems and experimentation. Sensors are good at memorising facts and are careful but may be slow.
    - Intuitive learners prefer principles, theories and discovering possibilities. Intuitive learners are good at grasping new content and can be quick but may be careless.
- Visual-verbal
    - Visual learners remember best what they see: sights, pictures, diagrams, symbols, films and demonstrations. They probably will forget something if it is said to them.
    - Verbal learners prefer sounds, words, hearing and discussing information. They remember much of what is said to them, they get a lot out of discussion, prefer verbal explanation to visual explanation and learn effectively by explaining to others.
- Active-reflective
    - Active learners prefer trying it out and seeing if it works. They do not learn in situation that requires them to be passive (e.g. in a lecture). Active learners work best in groups.
    - Reflective learners prefer to think it through first. They do not learn much in situations that provide no opportunity to think about the information being presented. Reflective learners work best alone
- Sequential-global
    - Sequential learners follow linear reasoning processes when solving problems. They prefer to move step-by-step through the material progressing logically to a solution. They learn best when material is presented in a steady progression of complexity and difficulty.
    - Global learners make intuitive leaps and may be unable to explain how they came up with solutions. They prefer to see the big picture and work intuitively and they sometimes do better by jumping directly to more complex and difficult material.

The Index of Learning Styles (ILS) tool is a self-assessing measuring tool consisting of 44 questions. The questions relate to the categories described within this section.

2.3.2.4 Fleming's VARK

Fleming (2001) defines a learning style as an individual's characteristics and preferred ways of gathering, organizing and thinking about information. VARK has the categories Visual, Aural, Read/Write, Kinesthetic and Multimodal. Fleming (2006) argues that it builds on the VAK inventories that have been around for many years and he states that VARK has added a second 'visual' modularity for read/write learners.

Fleming states that VARK is a questionnaire that provides users with a profile of their learning preferences. Fleming (2006) states that VARK above all is designed to be a starting place for a conversation among teachers and learners about learning.

Within VARK, the Visual learners are defined as ones that prefer maps, charts, graphs, diagrams, brochures, flow charts, highlighters, different colours and pictures. The Aural learners are defined as ones that like to explain new ideas to others, discuss topics, use audio recorders, attend lectures and discussion groups etc. The Read/Write learners prefer lists, essays, reports, textbooks, definitions, handouts, manuals and web pages etc. The Kinesthetic learners like field trips, trial and error, doing things, hands-on approaches and using their senses etc. In some cases learners will be categorised across these categories and this is described as the multimodal learning style type.

Various studies have taken place evaluating and using VARK as a tool for assessing learning style. For example, Drago et al. (2004) undertook a study using VARK to see how it applied to on-line learning. They suggested that online students are more likely to have stronger visual and read-write learning styles. They also found that read-write students and those that were strong across all learning styles were likely to evaluate course effectiveness lower than other students while aural/read-write learners and students that were not strong on any learning style were more likely to evaluate course effectiveness higher than other students.

The questionnaire proposed by Fleming contains 16 questions about how the learner prefers to learn to assess the appropriate learning style. The learner will then be provided with their learning style based on the answers. The learning style score can be any combination of V,A,R or K.

2.3.2.5 Dunn and Dunn Model

Within the Dunn and Dunn Model, the learning style is divided into 5 major strands called 'Stimuli' (Dunn and Dunn, 2003). These strands comprise of Environmental, Emotional, Sociological and Physical factors. Coffield et al (2004) highlight that Dunn and Griggs (1988) state that an important principle in the Dunn and Dunn model is the idea that students' potential and achievement are heavily influenced by relatively fixed traits and characteristics.

From these strands four variables affect the preferences and each have different factors (see Figure 4), as follows:

- Environmental:
    - Including sound, temperature, light and seating or room layout.
- Emotional:
    - Including motivation, degree of responsibility, persistence and need for structure.
- Sociological:
    - Including learning groups, help/support from authority figures, working alone or with peers and motivation from parent/teacher.

- Physical:
    - Including modality preferences (e.g. visual, auditory or kinesthetic), intake (food and drink), time of day and mobility.

This model measures preferences rather than strengths. Dunn and Dunn have produced many self-reporting instruments, examples of which are a learning style inventory for children and the Productivity Environmental Preference Survey (PEPS) for adults. The instruments identify strong preferences, preferences, non-preferences, opposing preferences and strong opposite preferences. The unique combination of these will result in identifying the learner's learning style.

Variable	Factors			
Environmental	Sound	Temperature	Light	Seating, layout of room, etc
Emotional	Motivation	Degree of responsibility	Persistence	Need for structure
Physical	Modality preferences – ie for visual, auditory, kinaesthetic or tactile learning (VAKT)	Intake (food and drink)	Time of day	Mobility
Sociological	Learning groups	Help/support from authority figures	Working alone or with peers	Motivation from parent/teacher

Figure 4: Coffield's variable factors for the Dunn and Dunn model

Coffield et al. (2004) suggest that the Dunn and Dunn model has a number of strengths, for example, it offers a positive inclusive affirmation of the learning potential of all students and it encourages the teacher to respect the different abilities of learners. They also state that it encourages a range of teaching and assessment techniques, and teachers and students to talk about learning. Coffield et al. (2004) also highlight some limitations to this model, which include:

- The model is based on the idea that preferences are relatively fixed and sometimes constitutionally based. The view that preferences are fixed may lead to labeling and generalisation.

- A belief that students should work with their strong preferences and avoid their weak ones may lead to self-limiting behaviour and beliefs rather than openness to new styles and preferences.
- How far can a self-report measure really ever be objective?

2.3.3 Criticisms of learning styles

Many researchers and educators have been critical about learning styles, for example the findings of Coffield et al. (2004) study discussed within the previous section of this thesis were mainly critical of the use of learning styles. Some of the limitations for each particular learning style are discussed in the previous section.

Coffield et al. (2004) state that most of the criticism comes from the fact that there is a lack of any common framework and this has resulted in confusion about their use. They also assert that no substantial, uncontested and hard empirical evidence exist and that the learning style matching approach has a significant positive effect on the students' achievement.

Coffield et al. (2004) also state that the critics of learning styles can be divided into two main camps. First, they state that there are those who accept the basic assumptions of the discipline (e.g. the positivist methodology and the individualistic approach), but who claim that certain models or certain features within a model do not meet the criteria of that particular discipline. They discuss the view of a second group of critics who adopt an altogether more oppositional stand. They also state that they do not accept the basic premise on which this body of research, theories, findings and implications for teaching has been built.

Coffield et al. (2004) state that the critics argue, "that the learning style theorists claim to 'measure' the learning preferences of students. But these 'measurements' are derived from the subjective judgments which students make about themselves in response to the test items when they 'report on themselves'". Basically saying that however much analysis is done, the foundations are shaky.

The learning styles measuring tools have also had criticism. Most of the learning styles have an online questionnaire, which the student must complete to obtain their learning style type. Additionally, Coffield et al. (2004) state that four criteria have to be fulfilled as a minimum standard for any instrument, which is to be used to redesign pedagogy. These criteria are construct validity, predictive validity, internal consistency reliability, and test and re-test reliability.

Nixon et al. (2007) state that one tutors could give them an impoverished view of pedagogy and so therefore tutors could end up seeing their role as being one of compliance, conformity and performance with standards set for them. Furthermore, they state that learning style models facilitate their promotion as models of 'good practice', even though there is little robust evidence in support of their effectiveness.

Further learning styles criticism has come from Popescu et al. (2007) who suggest that as learning is so complex it cannot be completely expressed by learning styles. They also argue whether Learning Styles have ever been proved to have some influence over learning. They therefore propose that it would be better to take the best of each model and use a complex set of features, each with its own importance and influence. With this in mind, Popescu et al. (2007) propose the Unified Learning Style Model (ULSM), which includes characteristics from various learning style models.

Although many have criticised learning styles to date there is no alternative to learning styles. The number of learning style models available show that there is a widely accepted belief that we do have certain characteristics that impact on the way that we learn given no other confounding factors and learning styles can reflect this.

2.3.4 Evaluation of learning styles for adaptability and personalisation

The learning styles research led to a further project objective of "to carry out an evaluation of learning styles for adaptability and personalisation" and this evaluation discussion is detailed within this section. The learning styles described in the previous section were evaluated for their suitability for use within an adaptability and personalisation system. The author previously published the evaluation study described within in this chapter (see Peter et al. (2008)).

Sampson and Karagiannidis (2004) define evaluation criterion for learning styles of measurability, time effectiveness and descriptiveness and prescriptiveness. This criterion was expanded for the purpose of this research and a detailed description of the criteria, how it was expanded and the evaluation of the learning styles follow.

Measurability:

How can we measure how a learner belongs to a particular category?

Specifically, to evaluate how will this be appropriate for a personalised learning environment.

It was found that all of the Learning styles evaluated for this research had an appropriate corresponding questionnaire tool and the number of questions for the tools ranged from the lowest of 12 (Kolb) questions through to the highest containing 100 questions (Dunn and Dunn).

Time effectiveness:

How many questions do we have to ask to see whether a user belongs to a category?

Additionally to extend this category: to evaluate whether the questionnaire is concise enough for the learner to be able to be prepared to answer it, but still having valid results for the personalisation to be created.

The results for this category are defined as High for the most time effective method to Low as the least time effective.

Specifically, the Learning Styles were assessed on how long it was felt the learner would have to take to undertake the questionnaire and the relevance of the questions to the particular personalisation required.

It was found that the Learning Styles with the least number of questions were Kolb (12 questions) and Fleming's VARK (16 questions) and therefore these would take the least time for the learner to complete. When assessing the relevance of the questions, however, the VARK questions came out as the most relevant and concise. For the purpose of personalisation, it was felt that the questions presented within Kolb would not be relevant, in particular, the questions looking at how the learner likes to learn (for example how the material is presented; for example sequential order etc.). With this in mind, this reduces the time effectiveness to Low for Kolb, as some other questions would need to be added for this learning style questionnaire to get the required results.

The other Learning Styles, Felder Silverman, Honey and Mumford and Dunn and Dunn have relevant and concise questions however they gained a lower ranking due to the number of questions within their questionnaires. Dunn and Dunn had a particularly low ranking due to the fact that the questionnaire contains 100 questions.

Descriptiveness and prescriptiveness:

The methodology should describe how learners are categorised and also how the learning material should be adapted for the learner.

Also specifically for this research: how has this been achieved in projects involved with personalisation and e-learning?

The learning style methodologies researched earlier described how learners are categorised and how these categories could be adapted for the specific learner within the system. A brief discussion of this follows:

Completing the Felder Silverman's tool categorises the learner style as Active/Reflective, Sensing/Intuitive, Visual/Verbal, Global/Sequential.

Papanikolaou (2003) states that ACE (Specht and Oppermann (1998)) uses this model in order to sequence learning materials according to a particular teaching strategy (learning by example, reading texts or learning by doing) based on learner's interests and preferences. Additionally, Stash (2007) states that CAMELEON (Computer Aided MEdium for LEarning On Networks, Laroussi and Benahmed (1998)) uses the Felder Silverman's model to categorise the learner according to their learning style.

The Dunn and Dunn tool categorises the learner styles as Auditory, Visual (pictures), Visual (text), Tactile Kinesthetic, Internal Kinesthetic, Impulsive, Reflective, Global and Analytical. Karagiannidis and Sampson (2004) highlight the ways that iWeaver (Wolf (2003)) have adapted the Dunn and Dunn learner styles to provide relevant representation types.

The Honey and Mumford's model categorises the learner style as Activist, Reflector, Pragmatist and Theorist. Sampson and Karagiannidis (2004) highlight how this has been used by INSPIRE to be able to select the content of material (i.e. activity-oriented, example-oriented) based on the activist, reflector, pragmatist and theorist categories.

Kolb Learning Style inventory categorises the learner style as Divergers, Assimilators, Convergers and Accommodators. Specifically, this learning style allows for an understanding of how the learner likes to basically learn. It allows for an understanding of how the learning material should be presented to the learner (for example in what order).

Stash (2007) states that APeLS (Canavan (2004)) applies both VARK and Kolb's model for presenting content to the learner – they are placed in two categories: all (i.e. meeting all requirements) or best (best fits the requirements).

Fleming's VARK is not a full learning style, however, it does have a tool that allows for categorisation of user's learning styles. Here the learning styles are categorised as: Visual, Aural, Read/Write and Kinesthetic. These categories are also some of the categories defined by Dunn and Dunn that have previously been represented according to the learning style.

Table 1 describes a summary of the research including the learning styles, measurability, time effectiveness and descriptiveness and prescriptiveness.

Although Kolb's learning style has the least questions it was found that it had low time effectiveness due to the fact that the questionnaire content was not relevant enough for the required personalisation to be created. With this in mind, further questions would have to be asked if this Learning Style were to be used and so therefore this would increase the time the learner would have to take to answer the questionnaire

Learning Style	Measurabililty	Time effectiveness	Descriptiveness and prescriptiveness
Felder Silverman's Index of learning styles	44 question instrument	Medium	Clear categories: Active/reflective, Sensing/Intuitive, Visual/verbal, Global/sequential Can be clearly mapped to type of learning/assessment material
Honey and Mumford	80 items with true/false	Low	Theorist, Activist, Reflector, Pragmatist Can be clearly mapped to content type of learning/assessment material (as INSPIRE)
Dunn and Dunn Model	Adult version questionnaire contains 100 items	Low	Environmental, Emotional, Sociological, Physical factors Can be clearly mapped to type of learning/assessment material (as iWeaver)
Kolb's Learning Style Inventory	12 questions	Low	Divergers, Assimilators, Convergers, Accommodators Difficult to map to type of learning/assessment: APeLS categorises All and Best
Fleming's VARK	16 questions	High	Visual, Aural, Read/write, Kinesthetic Can be clearly mapped to type of learning/assessment material

Table 1: Categorisation of learning styles

The outcome of this learning style evaluation was that Fleming's VARK will be the most suitable learning style methodology for use for offering personalisation and adaptability for the learner. The main reasons for this are firstly that the tool is by far the most suitable for measurability because it is the most concise tool as it has the least questions (apart from Kolb but the mapping is more complex for this) and also the most relevant questions. Secondly, the learning style categories can also be comparatively easily mapped to the type of learning material (this is compared to the Dunn and

Dunn learning style as this is more complex). They can be clearly mapped to the type of material required and not the content (as in the Honey and Mumford example) i.e. the type of material, for example, digital asset and not the content type, for example, an exercise or theory as this will be inferred based on the type of material that the learner is viewing.

2.4 Summary

The background research described within this chapter has demonstrated that the constructivism approach to learning and the heutagogical approach are a good "fit" within an e-learning environment and with the current type of learners using an e-learning technological environment.

Initially researching learning theories, the findings were that the constructivist learning theory fits with personalised and adaptive e-learning due to the fact that within e-learning it can be possible for the learner to be provided with learning content according to their needs and then construct their learning environment accordingly.

The teaching and learning approaches research found that pedagogy is not flexible enough or current for the technological learners of today due to the fact that it is teacher-led. Although andragogy does move forward and becomes learner-led, it does not incorporate enough self-discovery, which will enable the learner to take control of their learning. Heutagogy, on the other hand, allows for a more flexible learning arrangement. Within heutagogy, learners can take charge of their own learning and it is felt that this approach can be reflected within an e-learning environment effectively.

The research into learning styles highlighted that they have been categorised by many researchers including Curry (1983) and Coffield (2004). However it was found that there is still some confusion and criticism about what they are and how they are used.

Despite the criticisms from some researchers (described in detail by Coffield, 2004), it is felt that for the purpose of this research, incorporating learning styles into a model would be very useful when offering a learner a personalised and adaptive learning environment. The main reasons for this are that at present there is no alternative to learning styles and also the number of learning style models available demonstrates that there is a widely accepted belief that learners have certain characteristics that can impact on the way that they learn given no other confounding factors and learning styles can reflect this.

An evaluation of learning styles was undertaken in order to evaluate them for their suitability for use within a personalised learning styles. This evaluation fulfilled the project objective of "to carry out an evaluation of learning styles for adaptability and personalisation" which was highlighted as an objective during the research work.

The evaluation was based on the criteria proposed by Sampson and Karagiannidis (2004). The evaluation demonstrated that Fleming's VARK would be a suitable learning style to incorporate within a model offering personalisation and adaptability to the learner. The main reasons for this choice are that the VARK learning style offers a concise questionnaire for a learner to complete comprising of a minimum number of relevant questions and that the learning style categories map clearly to learning object file types. This mapping is in contrast to other learning styles, for example the approach taken by Dunn and Dunn in which the mapping will be more complex.

The research within this chapter therefore has selected VARK the type of learning style to be used for the mechanism, as defined in the hypothesis "a mechanism can be developed to personalise learning materials to an individual learner according to their learning style".

The research has also partly satisfied the aim of "to understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles" as the research aids an understanding of learning theories and styles and has demonstrated that the heutagogy approach will be a suitable learning approach for this model.

The objective of "to carry out a critical and comprehensive review of research within the area of e-learning tools, personalised and adaptive learning, and learning styles" is also partly satisfied within this research due to the fact it demonstrates a critical and comprehensive review of learning styles.

The research within this chapter has also led to a further project objective, which is to carry out a review of adaptive systems incorporating learning styles as it is felt that this would be useful for this research due to the fact that the research has also shown that learning styles have frequently been used within adaptive systems mainly to provide content based on the learning style category to the learner. These adaptive systems are described in more detail in Chapter 3, which describes how the learning styles are used within these systems. This review will be undertaken within the following chapter.

3 E-learning systems

3.1 Introduction

In order to achieve the objective of understanding the body of knowledge, this chapter describes the research into authoring tools, personalised and adaptive learning. The research also covers learning objects, metadata and tagging within e-learning.

Authoring tools for modern e-learning are dominated by e-learning platforms such as Blackboard (2008) and Moodle. These tools are integrated systems that support students and teachers within an e-learning environment. Other types of authoring tools exist and these include general authoring tools (e.g. HTML editors), adaptive hypermedia systems and general authoring tools. Two types of adaptive hypermedia systems categorised within the research are 'general adaptive hypermedia systems' and 'adaptive hypermedia systems incorporating learning styles'. All of these authoring tools will be described in more detail within this chapter and examples of the tools will be given.

The evaluation of adaptive hypermedia systems is also described within this chapter. Some evaluation techniques are described, for example the layered evaluation as proposed by Brusilovsky (2004).

Personalised and adaptive learning issues are also discussed within this chapter, in particular looking at what these terms mean and how can they be personalised to offer adaptive learning. Many attempts have been made to provide personalised and adaptable learning and this research will focus on personalised learning offered by popular e-learning platforms. This discussion is based on the evaluation of e-learning platforms based on the criteria proposed by Rego (2007), which have been extended. This evaluates both open source and commercial e-learning platforms specifically looking at the categories of functionality, adaptability and personalisation.

Metadata and tagging learning objects are also evaluated and particularly in the context of e-learning. Standards for metadata and tagging are analysed together with the technologies that can be used for this purpose. Systems incorporating tagging are also evaluated, and these are grouped as web annotation and tagging systems. Examples and issues concerning these systems are discussed.

Within the conclusion of this chapter the project hypothesis, aims and objectives will be revisited to see whether they have changed or have been satisfied by the research undertaken.

3.2 Authoring tools for education

Authoring tools for education can come in a variety of different formats. For the purpose of this research they have been grouped into the following types:

- General authoring tools for example HTML editors.
- E-learning platforms or Learning Management Systems for example Moodle.
- Adaptive hypermedia systems
    - General adaptive hypermedia system for example Interbook (Eklund and Brusilovsky (1999)).
    - Adaptive hypermedia systems incorporating learning styles for example INSPIRE.

Each type of authoring tool will now be discussed in more detail.

3.2.1 General authoring and editing tools

Treviranus (2008) states that authoring tools are very broadly defined to encompass any software application, tool, script, or wizard that produces web content. This includes:

- Editing tool specifically designed to produce Web content for example what-you-see-is-what-you-get (WYSIWYG) HTML and XML editors.
- Tools that offer the option of saving content in a Web format, for example word processors.
- Tools that transform documents into Web formats, for example, filters to transform desktop publishing formats to HTML.
- Tools that produce multimedia for the Web, for example video production and editing suites.
- Tools for site management or site publication, including content management systems (CMS), tools that automatically generate websites dynamically from a database and website publishing tools.
- Tools for management of layout, for example CSS, formatting tools.
- Web sites that let users add content, such as blogs, wikis, photo sharing sites and social networking sites.

Often, authoring tools are used by people with little technical knowledge and are designed to be simplistic for example HTML Pro (2008) and Hotmetal Pro (2002).

Brusilovsky (2003) defines two types of authoring tools, markup and form based. Authoring tools now contain more of a graphical interface as predicted by Brusilovsky (2003). Brusilovsky (2003) states that the final product of both markup and GUI approaches is the same and that the internal representation of knowledge and information in a set of specially structured files or, more often, a database. Furthermore he states that the authoring process is a bridge between the design and runtime stages, a process of getting the design inside the computer.

Common current authoring tools are e-learning platforms or learning management systems. Here an instructor creates the learning material, for example PowerPoint slides, multimedia, and then uploads this material to the e-learning environment. The following section looks at these e-learning platform environments in more details.

3.2.2 E-Learning Platforms or Learning Management Systems

Many terms are used to describe e-learning platforms and Learning Management Systems, for example Course Management Systems, Virtual Learning Environments and on-line tutor systems. Buednia and Hervas (2006) state that these products can be used to provide different ways of on-line education, and address several learning contexts, ranging from the conventional, classroom delivery to off-line, distance learning and on-line learning.

Kurzel et al. (2003) state that some desirable characteristics of emerging Learning Environments suggested by Maurer (2002) include:

- Re-usable content modules with searchable meta-data.
- Tools to create, combine and modify modules.
- Tools that allow the administration of the modules with statistical data being available.
- Communication facilities for the participants including chat and forums.
- Facilities that allow the use of the system for various learning paradigms and different levels of learners.
- Interactivity with powerful tools for testing and feedback.

Many different e-learning platforms exist and they can be either commercial or open source. Examples of commercial e-learning platforms are Blackboard (2002), IntraLearn (2001) and Angel (2005) and examples of open source e-learning platforms are Moodle, A Tutor (2005), Sakai (2004), LRN (2003), Ilias (2002). Limited evaluations of these platforms have taken place to date and, these will be discussed here in further detail.

Colace et al. (2003) undertook a study into commercial e-learning platforms. They propose a model to evaluate e-learning platforms and then evaluated common commercial e-learning platforms. They looked at Learning Management Systems (LMS), Learning Content Management Systems (LCMS) and the virtual environment for teaching and services associated with them. Colace et al. (2003) defined a LMS here as a system that integrates all the aspects for managing on-line teaching activities and LCMS is defined as being able to offer services that allow for managing contents – in particular their creation, importation and exportation.

The evaluation findings were that the commercial platforms that reached the most optimal performance in the evaluation had an LCMS (some examples of these were platforms Blackboard and Intralearn). They also found that having an LMS and LCMS could be complementary to each other. One outcome from the research by Colace et al. (2003) is that well performing e-learning platforms should have an LCMS.

Graf and List (2005) undertook a study into open source e-learning platforms specifically looking at adaptation issues. They state that adaptation has received very little coverage in e-learning platforms and they undertook to evaluate open source e-learning platforms to find the most suitable for extending to an adaptive platform. The conclusion for their research is that the platform Moodle outperformed the other platforms followed by the Ilias and Dokeos (Dokeos, 2004) platforms.

A further study was undertaken by Rego et al. (2007) who took the studies of both Colace and Graf and List further by researching into technical, adaptation and personalisation aspects, administrative, resources management, communication, evaluation, costs and documentation aspects of both commercial and open source e-learning platforms. Specifically during this research they undertook the evaluation of the commercial platforms of Blackboard, WebCT, IntraLearn, and Angel and the open source platforms of A Tutor, Moodle, Sakai and LRN.

During this study Rego et al. (2007) found that almost all platforms have good administrative and communication tools, compliance with standards, high implementation level and good documentation. The main weaknesses and problems were found with interoperability, reusability and quality of resources, learning domain, independence and extensibility of the platforms.

They also evaluated the adaptation and personalisation for the platforms and specifically the previous knowledge, courses and resources adaptability of the platforms. It was found that all evaluated platforms except the open source platform A Tutor had personalisation and customisation for the interface. It was also found that no platforms allowed for personalisation based on a student's previous knowledge and neither did they allow for course or resource adaptability.

A further interesting study into e-learning platforms was undertaken by Kurilovas (2005) who carried out an evaluation of several aspects of technical and pedagogical e-learning platforms and virtual learning environments. This study carried out an evaluation of a number of e-Learning platforms based on evaluation criteria that covered comprehensive technical and pedagogical aspects. The study concluded that Moodle had the following advantages over the other open source systems Ilias and A tutor:

- Moodle has a clear social constructivist philosophy and design
- Moodle has a modular and extensible architecture
- Moodle has a wide and lively developer and user community

Further research undertaken for this project is described in section 3.3.2. and this discusses some of the research in more detail and evaluates current e-learning platforms to see how much adaptability and personalisation is offered for the learner.

3.2.3 Adaptive hypermedia systems

According to Santally (2005), the concept 'adaption' or 'personalisation' is an important issue in research for learning systems. Systems that allow the user to change certain system parameters and adapt their behaviour accordingly are called 'adaptable'. Systems that adapt to the users automatically, based on the system's assumptions about the user needs are called 'adaptive'.

Brusilovsky (1996) states that adaptivity is of particular importance in the field of e-learning and gives two reasons for this. The first reason is that learners with different learning goals, learning styles, preferences, knowledge and different backgrounds, might use the e-learning system. The second reason is that the system can help the learner to navigate through a course of study by providing user-specific paths.

According to Brusilovsky (2002), adaptive hypermedia is an alternative to the traditional "one-size-fits-all" approach. Additionally, Brusilovsky (1996) states that adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user

Brown et al. (2009) state that these systems base their user models largely on existing knowledge and adaptation occurs at both the content level (adaptive presentation) and the link level (adaptive navigation). Adaptive presentation adapts the content of a hypermedia system to the user's goals, knowledge and other information stored in the user model. Adaptive navigation helps users to find paths by adapting to link presentations and functionality to the goals, knowledge, and other characteristics of a learner.

Brusilovsky (2007) states that one distinctive feature of an adaptive system is a user model. He states that the user model is a representation of information about an individual user that is essential for an adaptive system to provide the adaptive effect i.e. to behave differently for different users. Brusilovsky (2007) also states that the user's knowledge of the subject topic or domain appears to be the most important user feature for adaptive systems. Additionally, user interests, goals and background are also an important part of the user profile, according to Brusilovsky (2007). He also states that many individuals agree on the importance of modelling individual traits for the users, for example cognitive styles (how a learner prefers to organise and represent information) and learning styles (according to Brusilovsky they are typically defined as the way people prefer to learn). Furthermore, Sampson and Karagiannidis (2002) describe adaptive hypermedia systems as ones that build a model of the user/learner and apply it for adaptation for that user. They state that an adaptive system may adapt the content of a hypermedia page to the user's knowledge and goals, or to suggest the most relevant links to follow.

Thyagharajan and Nayak (2007) state that although these systems may tailor the educational offerings to the learner's objectives, prior knowledge, learning style and experience, they have been criticised for believing that embedding this expert knowledge is sufficient for effective learning to occur. They state that in reality the early adaptive systems constrained the learner and limited the opportunities for the learner to investigate topics that were deemed to be of little relevance.

Evaluating adaptive systems can be difficult and complex; this research will also describe evaluating adaptive systems, issues and frameworks later within this chapter.

3.2.3.1 General adaptive educational hypermedia

Research has shown that adaptive hypermedia systems can generally be put into two categories, adaptive systems that are systems containing one function and purpose and adaptive systems that have a number of functions and purposes.

Examples of current general adaptive hypermedia systems that contain one function are Interbook, ElmArt (Weber and Brusilovsky (2001)) and ActiveMath (Melis et al., (2001)). These systems comprise of adaptive e-text books based on a specific subject. For example, the adaptive content within Interbook uses an individual model of the user's knowledge and applies this to provide adaptive guidance, navigation, support and help for the user. Interbook stores an individual model for each user and provides adaptive guidance, adaptive navigation support and adaptive help. ElmArt is an intelligent tutoring system that supports a Lisp course from concept presentation to programme debugging. It was developed as an on-line intelligent textbook with an integrated problem-solving environment (Brusilovsky 1996).

There are a number of current adaptive hypermedia systems that contain more functionality and purpose and examples of these are Knowledge Tree (Brusilovsky (2004)), Alfanet (Santos et al., (2003)) and IClass (2004).

According to Brusilovsky et al. (2004), Knowledge Tree is a portal for learning support. They state that it provides access to resources within a hierarchy of course objectives provided by a course teacher. The interface is static, but it retrieves educational material from various servers, monitors learner activity and adapts to a user's level of knowledge.

Alfanet (Active learning for Adaptive internet) was developed within a European project from 2002 – 2005. It uses standards and provides details with pre-defined courses that can be altered during run-time specific user requirements. Alfanet has three different ways that it can adapt to the user's preferences, habits, features, interests and needs:

- Adaptation by the instructional design, which deals with providing different course contents, activities and services to the learner
- Adaptation of the interaction deals with providing support to the learners while interacting inside a course
- Adaptation of the presentation deals with presenting a different user interface to each learner according to his/her model

According to Turker (2006), the adaptive system IClass offers personalised learning experiences gained by the learner by way of learning support tools. It is suggested by Turker (2006) that the IClass project aims to establish a framework to deliver a personalised, adaptable and adaptive learning experience in a collaborative environment for learners. The system consists of a project planning tool, a reflection tool ("why" and "how"), collaboration tools (e.g. a forum) and a Google type search for research.

Brusilovsky (2004) points out that the limitations with the adaptive systems that support only one function (e.g. Interbook, ActiveMath) comes not from their performance but with the architecture. Brusilovsky (2004) states that as they only support one function there is a problem with integration and re-use support. He also states that they need to be treated as a whole and they cannot be used as components.

As for the adaptive hypermedia systems that support further functionality and purpose (e.g. Knowledge Tree, Alfanet and I-Class), limitations were found with the issue of flexibility. They also seem to be teacher led i.e. the teacher sets up the course and assessments and students do the assessments. Ideally, for a true e-learning platform the learner should be able to manage their own learning and have total flexibility over the learning materials. Due to these limitations, e-learning platforms are more commonly used than the adaptive hypermedia systems.

3.2.3.2 Adaptive hypermedia systems incorporating learning styles

A number of adaptive systems use learning styles to adapt the learning environment to the user. These adaptive systems include Adaptive Courseware Environment (ACE), Carmona (2007), CAMELEON, SMILE (Stoyanov and Krommers (1999)), INSPIRE (Intelligent Instruction System for Personalised Instruction in a Remote Environment), iWeaver and APeLS.

These systems will now be described in further detail including the particular learning styles used and how they are adapted for the learner.

Specht and Oppermann (1998) state that ACE is a web-based tutoring framework combining methods of knowledge representation, instructional planning, and adaptive media generation to deliver individualised coursework via the web. The ACE system adapts content to the learner based on the Felder Siverman’s Index of learning styles. They describe experimental studies within ACE, which showed that for successful application of incremental linking of hypertext, it is dependent on a student's prior knowledge and their learning style. Carmona and CAMELEON also adapt content to the learner based on this learning style.

The SMILE system is a web-based knowledge support system providing intelligent support for dealing with open-ended problem situations (Grigoriadou et al. (2001)). The SMILE system incorporates the Honey and Mumford learning style. The system utilises a learner profile that takes into consideration the learner's learning style, following the Honey and Mumford's categorisation (Stoyanov and Kommers (1999)).

Within INSPIRE the system aims to generate different lessons for each individual learner, to meet his/her goals. Papanikolaou (2003) describes the learner model within the INSPIRE system which controls the adaptive behaviour and has:

- An overlaid model that records the learner's knowledge level in the various goals
- The ability to record information that describes the learner's interaction with any content
- The ability to store information about the learner including the learning style preferences
- Transparency to the learner and so therefore the learner can manage the stored information
- The dynamic updating of the user model during the interaction so that the learner's current interactions can be stored in the database

The INSPIRE system also uses the Honey and Mumford's learning style and adapts the presentation to the learner based on their learning style. The learner initially completes the Honey and Mumford style questionnaire and the learner model records the categories: activist, reflector, theorist and pragmatist. Within the system, the learner can update the user model and the learner can have the ability to make decisions about the lesson content.

The iWeaver system is described as an interactive adaptive learning environment. The system adapts the presentation of the learning material based on the learner's style and follows the Dunn and Dunn learning style model. The system uses the categories of the Dunn and Dunn model and recommends the representation file type accordingly. iWeaver supports the teaching of a programming language and it offers a combination of adaptive navigation and adaptive content presentation techniques.

A system developed according to the APeLS framework matches the user model with content metadata in order to select the learning objectives that are most relevant to the user's learning style given certain alternatives in the pool of resources (Brusilovsky 2007). This system presents learning material based on style and presenting sequencing. The learning styles used within this system are VARK, Kolb and Honey and Mumford.

It was found during the research that one of the most common uses of learning styles within e-learning systems is to adapt the learning material presented to the user based on their learning style category (summarised in the information in Table 2).

During the research it was also found that some systems for example the Adaptive Hypermedia Architecture (AHA) system (De Bra and Calvi (1998)) and the Mulimedia Asynchronous Networked Individualised Courseware (MANIC) system (Stern et al. (1997)) go further and propose systems that provide mechanisms for inferring learner's preferences.

Despite the systems that have been developed, Brusilovsky and Millán (2007) state, "there are no proven recipes for the application of learning styles in adaptation". Brusilovsky and Millán (2007) also state that it is still unclear which aspects of learning styles are worth modelling, and what can be done differently for users with different styles. Furthermore, Carmona (2007) states that the reason for this may be that the tool used gives some grade of uncertainty and that the assumptions made about the learning style are not updated in the light of the students interaction with the system.

Also, Carmona (2007) states that the rules defined are fixed even when the behaviour of the student shows something wrong with these rules.

Therefore, they state that it is unable to adapt itself in the light of new information.

Brusilovsky and Millán (2007) therefore state that to progress with this area, it is necessary to learn more about the relationships between user traits and possible interface settings, or to develop other techniques for the adaptation.

Learning Style	Adaptive system	How LS is used
Felder Silverman's Index of learning styles	ACE	To adapt content presentation to learner
	Carmona	
	CAMELEON	
Honey and Mumford	INSPIRE	To adapt the presentation of learning
	SMILE	Used to utilise a learner profile
Dunn and Dunn Model	iWeaver	Adapts presentation of learning material based on learner's style
VARK, Kolb, Honey and Mumford	APeLS	Presenting learning based on style and presenting sequencing

Table 2: Learning styles, systems and purpose

A further research project undertaken by Graf and Kinshuk (2007) has adapted content to the user based on their learning style. The learning style used within this project is the Felder Silverman style model. This project evaluated the effect of the adaptability on the learners and the outcome was that the adaptability had a positive effect on the learners. The study demonstrated that the adaptive model helped the students to learn more effectively and so therefore this facilitates learning.

3.2.4 Evaluating adaptive hypermedia systems

Tintarev and Masthoff (2009) state that evaluating adaptive systems is not easy to achieve. Some researchers have also pointed out some pitfalls with this, including Masthoff (2002) and Weibelzahl (2005), who highlight the difficulty of defining the effectiveness of adaptation, and that too much emphasis is put on summative rather than formative evaluation. One other pitfall highlighted is that often insignificant results are generated due to too much variance between participants.

Some evaluation techniques for adaptive systems have been proposed, for example Bernard et al. (2009) put forward an evaluation framework for the adaptability of a system called an online AnAmeter framework. He argues that this is a tool that facilitates the evaluation of adaptability that obtains a quantitative evaluation of variables called global, semi-global and local adaptation degrees.

In addition to this, Brusilovsky (2004) provides a layered evaluation of adaptive learning systems. This is called the layered evaluation framework where the success of adaptation is addressed at two distinct layers:

- User modelling
- Adaptation decision making

The two layers are now discussed in more detail:

User modelling:

> The goal of the user modelling phase is to reach high-level conclusions concerning the aspects of user-computer interaction that are considered significant for the particular application.

Adaption decision making:

> In the adaptation decision making phase, specific adaptations are selected, based on the results of the user modelling phase, which aim to 'improve' selected aspects of interaction.

According to Brusilovsky (2004), these two processes are closely interconnected, since adaptation decision making takes input from the results of the interaction assessment. They also state that they are also independent as the same user modelling outcomes may result in significantly different adaptation decisions.

Magoulas et al. (2003) state that the layered evaluation mainly evaluates adaptive systems by deriving appropriate models or architectures of adaptation, which differ in the resolution degree of their decompositions or processing steps. They highlight that this is in contrast to some approaches that focus on the overall user's performance and satisfaction, for example Chin (2001). They highlight that layered evaluation in particular assesses the success of adaptation by decomposing it into different layers, and evaluating them one by one. They also state that this approach provides advantages over other methods. One example is that it evaluates each adaptive stage separately, which gives a useful insight into the success or failure of each adaptation.

Another evaluation approach is to evaluate using heuristics. According to Magoulas et al. (2003), "Among a wide range of the techniques for usability evaluation, heuristic evaluation is a widely accepted method for diagnosing potential usability problems and is popular in both academia and industry". Using this approach enables evaluators to detect usability problems easily. This methodology is based on a user evaluating an interface based on the heuristics as defined by Nielsen (1994).

The revised sets of 10 heuristics are as follows (Nielsen):

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose and recover from errors
10. Help and documentation

Magoulas et al. (2003) propose an integration of Brusilovsky's (2004) layered evaluation approach and a modified version of Nielsen's (1994) heuristic evaluation and they propose the following:

1. The visibility of the Adaptive Learning Environment:

   e.g. concerned with how the adaptation in the system attracts the user attention.

2. The match between adaptive learning environment and the real world:

   e.g. can the learning environment provide or present information that matches the individual's learning preferences.

3. The levels of learner control:

   e.g. are the learners are free to develop their personal strategies or change their learning models?

4. The consistency and standards:

   e.g. learners still have the same interaction with the system and this is not affected by the adaptation.

5. To help users recognise, diagnose and recover from errors:

   e.g. can the system help a user to recover from an error?

6. Error prevention:

   e.g. the adaptive element helps the user to not make any errors.

7. Recognition rather than recall:

   e.g. are the system instructions clear?

8. Flexibility and efficiency of use:

   e.g. how quickly the system can accommodate the learners' preferences.

9. Aesthetic and minimalist design:

   e.g. effective design to improve the usability of the system.

10. Searchable help functions and documentation:

    e.g. help is relevant and concise.

This combination of heuristics and layered approach proposed by Magoulas et al. (2003) is thought to be a good fit when evaluating adaptive systems.

3.3 Personalised and adaptive learning

3.3.1 Personalised and adaptive learning issues

Costello et al. (2009) state that personalised learning means high quality teaching that is responsive to the different ways that students can achieve their best results. They state that a learning environment that responds to individual pupils, with materials chosen to take account of their needs, interests and aspirations can lead to an enhanced learner experience.

Furthermore, Hummel (2004) states that building individualised learning activities to support personalised instruction in an adaptive environment is a big challenge. They state that the web can offer the perfect technology and environment for individualised learning, since learners can be monitored, supported and assessed online.

Martinez (2000) suggests that there are many ways to personalise learning and proposes five levels of a personalisation strategy and they are:

- Name recognition:

  Basic personalisation of storing and using the learner's name

- Self-described:

  Here the learners describe their preferences through use of questionnaires and surveys for example.

- Segmented:

  The learner uses demographics, common attributes or surveys to put learners into manageable groups (e.g. student course details).

- Cognitive-based:

  This uses information about the cognitive process, strategies and ability. For example, this could be based on the learner's file type preference (as per their learning style).

- Whole-person based:

  This uses learning orientations. In this example, as the learner learns, the system collects data, tracks progress and compares responses and common patterns to improve responses. Requires real-time using inferential technology.

It is felt that an effective personalised learning environment should offer the learner personalisation at all of these levels of personalised learning.

Many attempts have been made to provide personalised and adaptable learning but it is unclear what is really meant by personalised and adaptable learning. Often personalisation may only mean interface personalisation, for example a colour scheme change or a language change according to the user's needs. However, there are also systems with content personalisation that will require learning objects to be authored for personalisation and offered to the learner based on their requirements.

As far as personalised systems are concerned, Karagiannikis and Sampson (2004) state that they can be defined by their capability to adapt automatically to the changing attitudes of the "learning experience" which can, in turn, be defined by the individual learner characteristics, for example the type of learning material. They also suggest that personalised systems can be quite diversified according to their adaptation logic, depending on the requirements of the specific learning content.

An example given (Brusilovsky 2001) is that the personalised learning determinates can include learner's characteristics, which can, in turn, include learner's background, expertise, prior knowledge, skills, requirements, preferences etc.

Learners and instructors use e-learning platforms and so therefore it is felt that it would be beneficial to evaluate these platforms to see how much personalisation and adaptability they offer. This evaluation is described in detail in the next section.

3.3.2 Evaluation of the personalisation and adaptability offered by popular e-learning platforms

Common open source and commercial e-learning platforms are known to offer course management facilities for the instructor and learner, but for this project it was felt important to find out how much personalisation or adaptability e-learning platforms actually offer the learner. This therefore led to a further project objective of "to carry out an evaluation of the personalisation and adaptability offered by e-learning platforms" and this evaluation follows.

For this research, it was decided to evaluate some of the most commonly used platforms at the time of the research. Therefore, it was decided that the commercial platforms to be evaluated for this study were Blackboard, Intralearn, Angel and Saba and the open source platforms chosen were Moodle, A Tutor, Sakai, LRN and Ilias. The author published this evaluation study in 2009 (see Peter et al (2009)).

The e-learning platform evaluation criteria proposed here is one that extends the evaluation criteria that was proposed by Rego et al. (2007), which is described in Section 3.2.2.

The criteria used for the evaluation extends Rego's criteria as it evaluates how much adaptability and personalisation the e-learning platforms actually offer. The evaluation criteria proposed here is grouped within three categories and these categories are Functionality, Adaptability and Personalisation.

The functionality category evaluates the functionality offered by the e-learning platforms for the instructor to manage course material and sequence and for the instructor to manage and monitor learners. It also evaluates whether the learner is able to search for learning objects.

The adaptability category evaluates whether it is possible to extend the content provided by the e-learning platform so that it can be adapted to the learner's specific needs based on their goals and behaviour. It also evaluates whether the learning content could be provided to the learner based on their specific learning style.

The personalisation category specifically looks at the user interface personalisation, learning style content personalisation, learning style object type (e.g. video file type, podcast file type, PowerPoint file type) personalisation and the also the course structure personalisation available in the e-learning platforms.

Therefore, the evaluation category for this research are proposed as follows:

Functionality available (F):

1. The extent to which the instructor can manage course material and sequence (F1)
2. The extent to which the instructor can manage and monitor learners (F2)
3. Whether the learner is able to search for Learning objects (F3)

Adaptability (A):

Can they adapt to the learner's specific needs including:

1. The learner's goals (A1)
2. The learner's behaviour (A2)
3. The learner's learning style (A3)

Personalisation (P):

Can they offer a personalised learning experience including:

1. The extent to which they offer user interface personalisation (P1)
2. Whether the learning content can be provided for their specific learning need (P2)
3. Whether the learning object type can be provided based on their specific learning needs (P3)
4. The extent to which the course structure is personalised according to their specific requirements (P4)

E-learning platforms evaluation results

The evaluation took place and the following measure was used:

0: none, **1:** some but limited, **2:** good

The results are summarized in table 3. However, here follows a description of the final evaluation results for each category:

The **Functionality** category findings:

It was found that all of the platforms offered good tools for the instructor to manage course material and material sequence and also to enable the instructor to manage and monitor learners. Therefore all platforms received the high score of 2 for F1 and F2.

It was also found that three platforms offered some kind of learning object search for the learner. Specifically, A Tutor, Ilias and Saba offer the sharing of learning objects, however, although this is possible it does not allow for the learner to be provided with them within a learning package and additionally a limited search criteria was available for this object search. With this in mind, these platforms were given a score of 1 for F3 as it was felt that although some access was allowed it did not give total management and flexibility for the learning objects.

E-Learning Platforms	F1	F2	F3	A1	A2	A3	P1	P2	P3	P4	Total score
Criteria	Instructor can manage course material and sequence	Instructor can manage and monitor learners	Learner is able to search for Learning objects	Adapt to learner's goals	Adapt to learner's behaviour	Adapt to learner's learning style	User interface personalisation	Learning content specific to their specific learning need	Learning object type specific to their specific learning needs	Course structure according to their specific requirements	
Blackboard	2	2	0	0	0	0	2	0	0	0	6
IntraLearn	2	2	0	0	0	0	2	0	0	0	6
Angel	2	2	0	0	0	0	2	0	0	0	6
Saba	2	2	1	1	0	0	2	1	0	0	9
Moodle	2	2	0	0	0	0	2	0	0	0	6
ATutor	2	2	1	1	0	0	1	1	0	0	8
Sakai	2	2	0	0	0	0	1	0	0	0	5
LRN	2	2	0	0	0	0	2	0	0	0	6
Ilias	2	2	1	1	0	0	2	1	0	0	9

Table 3: E-learning platform evaluation results

The **Adaptability** category findings:

It was found that generally very little adaptability was offered by the learning platforms. For the first criteria A1 (which was that the system could adapt to the learner's specific needs) it was found that only the A Tutor, Ilias and Saba platforms allowed for this (and in a very limited way) due to the fact that the learner could undertake a basic search for learning objects. These platforms were therefore given a score of 1 for this as they only had limited functionality.

It was found, however, that none of the platforms evaluated allowed for adaptability based on the learner's behaviour or an individuals learning style. Therefore all of the platforms evaluated received a score of 0 for A2 and A3.

The **Personalisation** category findings:

It was found that for the first criteria evaluated P1 (which was the user interface personalisation), all platforms provided this and the personalisation offered ranged from interface layout, interface schemes and language choices. Specifically, A Tutor gained some but limited in this category as it does not offer interface personalisation but does offer a language choice and Sakai gained some but limited as it offered the interface personalisation but not the language choice. This outcome was expected as Rego et al. (2007) also found in his study that most of the platforms evaluated allowed for this level of personalisation.

For the next criteria P2 (providing the learning content to their specific learning need) A Tutor, Ilias and Saba platforms offered a limited amount for the learner due to the fact that they can search for appropriate learning objects.

The last personalisation criteria P3 (learning object type specific to their specific learning needs) and P4 (course structure according to their specific requirements) were not found to be available at all in any of the e-learning platforms evaluated. Therefore all platforms received a score of 0 for P3 and P4.

Figure 5 shows the results of the evaluation and the overall scores for the platforms. It can be seen that not one platform gained over half of the available scores and this was due to the fact that they all provided very limited personalisation and adaptability for the learner. A Tutor and Saba gained the marks in the personalisation and adaptability categories due to the fact that they provide the user with the ability to search for learning objects based on their own requirements. These search functionalities have very limited search criteria available however.

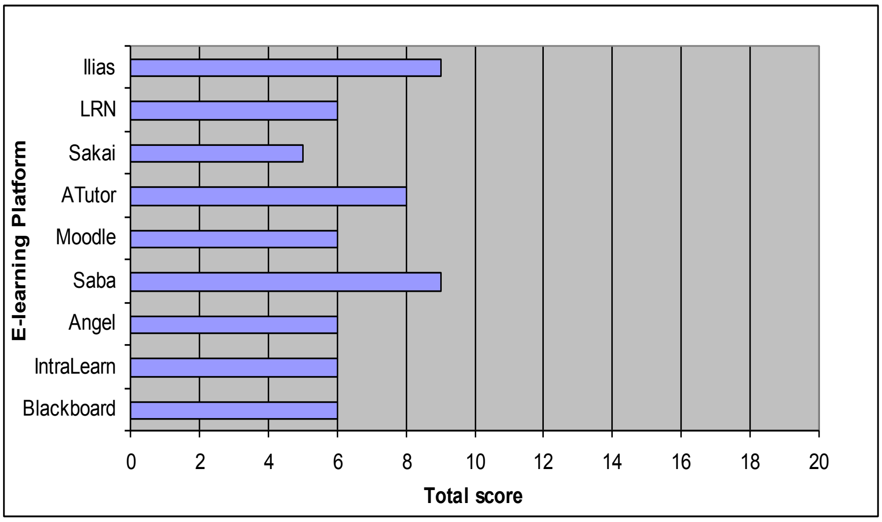


Figure 5: E-learning platforms and their overall score

This functionality offers limited personalisation, however, due to the fact that the learners cannot create their own specific course structure out of these learning objects. It was found also that none of the platforms evaluated offered any personalisation based on the learners learning style.

The outcome of this evaluation, therefore, is that it has demonstrated that none of the evaluated platforms can offer a truly personalised experience for the learner.

The learner and instructor are provided with the tools for course management and learning management. These tools are inflexible, however and do not cater for the specific needs of the learner. The platforms provide very limited personalisation and this is mostly for interface personalisation rather than actual content personalisation.

3.4 Tagging objects and standards

3.4.1 Learning objects and learning object repositories

The IEEE Learning Object Metadata (2002) defines learning objects as “entity digital or non digital, which can be used, re-used or referenced during technology supported by learning. Examples of learning objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning".

Many other definitions exist for learning objects, for example:

- Hummel et al. (2004) define a learning object as "any digital, reproducible and addressable resource used to perform learning or support activities, made available for others to use"

- Wiley (2002) state that a learning object is any digital resource that can be reused to support learning.

Santally and Senteni (2005) state that learning objects are often used as components to assemble larger learning modules or a course, depending on different educational needs. They call the assembly of these learning objects content packaging.

Furthermore, Polsani (2003) promotes that there is a broad understanding among the members of the learning object community about the functional requirements of learning objects, which are:

- Accessibility: that the learning object should be tagged with metadata so that it can be stored and referenced in the database.
- Reusability: once created, a learning object should function in different instructional contexts.
- Interoperability: the learning object should be independent of both the delivery media and knowledge management systems.

Conlan et al. (2002) states that there are a number of factors that increase the potential reuse of learning content:

- Granularity of the content
- Effective and descriptive metadata
- Appropriate packaging of the content and metadata for distribution

They point out, however, that these factors do not directly improve the pedagogical quality of the content produced.

According to Lehman (2007) a learning object repository is “an electronic database that accommodates a collection of small units of educational information or activities that can be accessed for retrieval and use”. Lehman (2007) categorises the learning object repositories as general, discipline specific and commercial/hybrid. Examples of general learning object repositories are Ariadne, Merlot and Jorum, an example of a discipline specific learning object repository is Math Forum and an example of a commercial/hybrid learning object repository is XanEdu which provides learning resources for instructors and instructional designers.

As far as the general learning object repositories are concerned, Ariadne provides access to learning resources from different repositories, e.g. Open Educational Resources (OER). Merlot (Multimedia Educational Resource for Learning) provides searching for learning objects based on keywords within subject groups, however does not provide content for a learner based on a specific criteria. Jorum allows for searching learning objects by subject, issue date, author, title and keyword. All of these systems use metadata to enable the search.

3.4.2 Metadata and standards

Metadata is widely described as “data about data”. Examples of metadata for learning resources or objects may be author, description and topic. It is generally felt that clearly structured and designed metadata should enable the effective reuse of learning resources. In particular, it should allow for good search and document retrieval techniques to be developed.

Bateman et al. (2007) state that they subscribe to the notion that metadata is best created if it focuses on a particular goal, is contextualised to a particular user, and is created in an ambient manner by observing the actions and interactions of students in learning environments.

Standards for metadata descriptions for learning resources have been developed and the most widely used are IEEE LOM, Dublin Core metadata initiative (2008) and Advanced Distributed Learning (ADL) SCORM (2001).

The IEEE Learning Object Metadata (LOM) is a model for metadata descriptions for learning resources in a hierarchy which has 60 elements organised into 9 categories, which are general, lifecycle, meta-metadata, technical, educational, rights, relation, annotation and classification. Each of these data elements has a specified name, explanation, size, example, data type and other key detail. IEEE state that the purpose of the project is to enable learners or instructors to search, evaluate, acquire and utilise learning objects across any technology supported learning systems.

The Dublin Core Metadata initiative allows for the description of web resources. The metadata attributes defined are very simplistic and consist of description, title, date, format, language and contributor. Forsberg and Dannstedt (2000) state that they found an issue when applying the Dublin Core, which is that, the context of the learners' create and consume information, is not taken into account.

ADL SCORM (Shareable Content Object Reference Model) is a standard for metadata that enables the description and reuse of learning content. It extends the IEEE LOM model and the Dublin Core Metadata initiative. The SCORM constitutes three key components and they are the content aggregation model (CAM), the run-time environment (RTE) and content packaging. Conlan (2002) states that the ADL SCORM aims to meet the high-level requirements of reusability, accessibility, durability and interoperability.

Dagger et al. (2003) state that although these current standards use metadata to mark learning resources, one of the restrictions is that the metadata is too low level to capture the context semantics of the learning resource. Mason and Ellis (2009) state that the SCORM standard has limitations that are commonly discussed in research literature. They state that Mustaro and Silveira (2007) highlighted the fact that SCORM does not support the sequencing of learning object components adequately to support adaptive learning.

Therefore, in order to develop a system that enables adaptive learning capabilities; if SCORM is required then it is necessary to extend it for this purpose. Mason and Ellis (2009) describe in detail the three ways that ADL (2004) propose it is possible to extend the SCORM model:

(a) The first approach is to add new metadata elements to the defined LOM categories. Existing elements cannot be replaced and new elements must not have the same meaning as existing elements.

(b) The second approach is to add new vocabulary values beyond the IEEE LOM values defined within the documentation.

(c) The third approach is to reference an internal or external XML document file using the ADL <location> element.

As far as metadata and e-learning is concerned, attempts have been made to categorise the representation of metadata in e-learning applications. Al-Khalifa and Davis (2006) propose the following categorisation:

- Standard metadata:

  This metadata is found in applications that use IEEE-LOM standard or a variation of it e.g. National Repository for Learning objects which is intended to encourage a community of sharing learning resources.

- Semi-semantic metadata:

  This metadata is found in applications that use the IEEE-LOM standard with an extended semantic component e.g. the Hypermedia Learning Objects System that uses IEEE-LOM to describe it's learning resources and extends the relational field in the standard with a semantic net to interconnect different learning objects.

- Semantic metadata:

  This metadata is found in these applications that rely on domain ontologies to define their metadata. They use RDF (2002) to express the semantics of the learning resource. Al-Khalifa and Davis (2006) state that one example of this is Advanced Research in Intelligent Educational Systems (ARIES) (Brooks and McCalla (2006)) which replaces the IEEE-LOM with more flexible approach that sees metadata as the process of reasoning over observed interactions of users with a learning object for a particular purpose.

Al-Khalifa and Davis (2006) state that the decision of which metadata representation to choose comes down to a number of factors and these factors will depend on the application scope and needs. They state that standard LMS's may prefer using standard metadata for its semantic whereas nonproprietary systems may want to move towards semantic metadata.

Furthermore, they also state that Brooks and MacCalla (2006) have highlighted three issues relating to metadata standards:

- Metadata standards were created with human beings being both the consumer and producer of the metadata so the metadata field needs to be only understood by humans.
- Metadata standards are inherently centralised. In order to have interoperability, all applications must adhere to the same application profile.
- Metadata standards collect the wrong kind of data. Often, for example important information such as usage of the learning object is often neglected.

Al-Khalifa and Davis (2006) also argue that the following are the advantages that semantic metadata has over standard metadata:

- Machine processable metadata due to the fact that they are built on ontologies
- Flexibility and extensibility as it does not contain a fixed template

- Reasoning as the metadata is expressed formally so reasoning rules can be applied
- Interoperability due to being built on agreed ontologies

As for technical specifications of metadata, Nilsson et al. (2002) state that most of the learning technology specifications for metadata define metadata use XML document instances. They state that this includes IEEE LOM and ADL SCORM.

Nilsson et al. (2002) state that Dublin Core is a notable exception and this user RDF for the basic elements, qualifiers and educational elements. They argue that XML is not as flexible as RDF for expressing metadata. However, there still has not been a large uptake of RDF due to development and compatibility issues. XML and RDF are discussed in more detail in the next section.

3.4.3 XML, RDF and OWL

It was found during the research that the exciting developments of the semantic web are enabling developers to consider some new approaches towards developing personalised systems.

Tim Berners-Lee (2001) described the semantic web as "a new form of web content that is meaningful to computers that will unleash a revolution of possibilities". The intention being that computers will understand the meaning of data: i.e. understanding, describing and manipulating the meaning of data and the relationships between data.

Generally, the current technologies for the semantic web are XML, RDF and web Ontologies. XML (eXtensible Markup Language) allows users to give structure to documents but does not allow for meaning whereas RDF (Resource Description Framework) allows for meaning to be added. W3C states that RDF is a model describing qualified or named relationships between two web resources or between a resource or a literal.

W3C defines that RDF statements are composed of a resource, a named property and the value of that property for that resource. The statement parts described are the subject, predicate and object i.e. a triple.

A triple example for a particular learning material and an author could be as follows:

The tutorial exercises as subject
The material author as predicate
Fred Smith as object (i.e. the actual author name)

Many RDF software development tools are currently available, including isAViz (2004). This particular tool allows the user to design the RDF diagrammatically and the RDF is then generated.

Using XML and RDF it is possible to give structure and meaning. However, it is not possible to add reasoning and define concepts. This is where ontologies come in. An example of a problem that an ontology could manage is that one database could hold some data for a piece of learning material called 'Creator', and another could hold some data for a piece of learning material called 'Author' and essentially they are meaning the same thing. The ontology can contain a rule stating that the concepts 'Author' and 'Creator' are the same and so will therefore allow the data to be treated in the same way.

W3C are currently proposing the following as ontologies to use for the semantic web: RDF schemas, SKOS (1997) and OWL (2003). Some ontology development tools are Swoop and Protégé. For this project the Protégé tool was evaluated and initially it was thought that it could be a suitable tool to use for the development of the ontology for this project.

Daconta et al. (2003) state that ontologies consist of concepts and relationships between them and they are usually implemented as classes, relations, properties, attributes and values. They also depict the relations between entity focused concepts e.g. employee_of managed_by etc.

Here is a very simple example of an ontology describing the Class lecturer who has a Subclass person and who contains two attributes (lectures, works_at):

Simple ontology
Class Lecturer:
Subclass_of: Person
Lectures: <field>
Works_at: <institution>

Instance Fred Smith
Instance_of: Lecturer
Lectures: <field instance: <computing>>
Works at: <institution instance: <The University of Greenwich>>

Intension (I): Lecturer(X), where X is a variable for the domain (person)
Extension (E): {Fred Smith...} the actual set of instances/individuals who are X for who it is try Lecturer(X)

Where ***I*** is the taxonomy, schema, conceptual/object model, ontology.

Where ***E*** are the leaves of the taxonomy (the bottom most objects in a taxonomy), tuples, instances, the extension and individuals.

The research into the semantic web for this project led to an interest in the work of Stanford University and examples of semantic web prototype implementations that they have developed. In particular, the Protégé software (1997) can be used as a tool to model the ontology and semantic rules.

3.4.4 E-learning systems incorporating tagging

Generally it is felt that tagging systems can provide the opportunity for learning object metadata creation. Bateman et al. (2007) make the distinction between web annotation systems and tagging systems, both of which provide the opportunity for metadata creation.

Furthermore, Bateman et al. (2007) assert that these two approaches can improve some typical activities in learning for example, revising learning material and connecting with peers. Systems that incorporate both of these approaches are the Open Annotation and Tagging System – OATS (Bateman et al. (2006)) and iHelp Presentation application (Bateman et al. (2007)). The OATS system adds tagging from within text-based learning content and iHelp extends this to multimedia content.

Web annotation systems and systems incorporating tagging will be described in more detail within the next section.

3.4.4.1 Web Annotation Systems

Bateman et al. (2007) state that web annotation systems fall into two categories; those for single users to organise and share information and those for collaborative exchange and creation of information between users.

An example of single user web annotation systems is Marginalia (Xin and Glass (2005)). This system focuses on providing functionality for any web page and allows users to add comments on selected text on a web page, which may be marked as private or public.

An example of the collaborative web annotation system is Annotea (Koivunen (2005)). Bateman et al. (2007) state that this is a system, which enhances the collaborative development of the semantic web via shared web annotations. Example of annotations could be comments or notes.

Bateman et al. (2007) state that AnnotatEd (Farzan and Brusilovsky (2006)) is an excellent example of a web annotation system. It allows for annotations and "social navigation support" which allows for users to provide clues to other users to help guide students to the most widely used or heavily annotated documents. They state that this is similar to suggesting tags in collaborative tagging systems.

3.4.4.2 Systems incorporating tagging

Tagging systems can either be traditional tagging systems or collaborative tagging systems. Li and Lu (2008) define collaborative tagging as a process where users add and share tags (i.e. keywords) to other shared items, such as online photos. They state that there are two prominent challenges in today's collaborative tagging systems: inconsistency and ambiguity. These are caused by polysemy (where a word has similar but different definitions) and synonymy (where various words have the same definition). They define a number of approaches for collaborative tagging:

Formal taxonomy or ontology:

> FolksAnnotation is a system that extracts tags from del.ocio.us and maps them to various ontology concepts found that can be derived from tags (Al-Khalifa and Davis (2007)). Yahoo also has a similar study that focuses on an ontologically driven data mining approach.

Statistical and pattern analysis:

> Golder and Huberman (2006) using statistical and pattern analysis gave an in-depth analysis of del.icio.us (2003) tags and they found that tag clouds in del.ocio.us serve as limitations for users who are uncertain about how to tag a particular resource because tag clouds offer only a limited number of tags.

Social networking:

> Attempts have been made to incorporate social network knowledge into collaborative tagging to improve the understanding of tag behaviours. For example, on the collaborative tagging site Flickr (Flickr), the users are allowed to map their own tags to other tags on their friends' pages.

Visualisation:

> Some researchers have used visualisation. For example, Cloudalicious (Russell (2006)) illustrates the tag clouds or folksonomies as they develop over time for a given URL.

Bateman et al. (2007) state that learning material is typically hypertext based, and mostly includes text, images and links and learners may often bookmark these and del.ocio.us, for example, may be a suitable tool to use for this as Del.ocio.us is a social bookmarking system that allows for the user to annotate bookmarks with free-text keywords. Within social bookmarking systems, often some aggregated information about a user's bookmark is provided using a tag cloud. Michlmayr and Cayzer (2007) claim that tag clouds fail to represent two important properties of a user's bookmark collection:

- They do not represent relationships between the tags
- They do not consider that tagging data is time-based in their weighting of the relative importance of the tag.

Carmagnola et al. (2007) describe how some systems are incorporating collaborative tagging:

- Ahn et al. (2006) use social annotation to improve information visualisation by presenting visual indicators that provide information about user and group annotations of resources.
- A framework for integrating social tagging into natural language ontology is proposed by Bateman et al. (2006).
- Xu et al. (2006) have developed a system in which objects are tagged for adaptation.

When analysing tagging in terms of the classical Bloom's taxonomy of Learning (Bloom (1956)), Bateman et al. (2007) also state that learner's who use tags show evidence of moving up the hierarchy from the lower "consumption" based levels of learning (knowledge and comprehension) to higher levels of applied and meta-cognitive knowledge (application and analysis). They state that the reviewing of tags (i.e. comparing tags used by a community of taggers) would potentially facilitate a move to the highest level of Bloom's Taxonomy of Learning (synthesis and evaluation).

As far as e-learning is concerned, Bateman et al. (2007) confirm that they believe that collaborative tagging systems have the potential to be a good fit with an e-learning system because:

- E-learning platforms or LMS's currently lack sufficient support for self-organisation of learning objects.
- Collaborative tagging has the potential to enrich peer interactions as per awareness centred on learning content.
- As tagging is a reflective process, it gives students opportunities to summarise new ideas while receiving peer support.
- Tags provide an insight into learner's comprehension and activity, which could be useful for instructors to assess.

A tagging system proposed by Carmagnola et al. (2007) uses tagging for the user model to infer the following:

- The user's interactivity level: how much the user interacts with the system.
- The user's organisation level: how the user organises and categorises things.
- The user's interest in particular content: if a user spends time in selecting or inserting tags on a specific item they may be interested in the item.

Despite all this, according to Bateman et al. (2007) tagging is largely unemployed in e-learning. They state that popular web-based learning management systems such as WebCT, Blackboard, Moodle and Sakai lack any native use of tagging. Since this statement, it was found by the author that Moodle has now added the ability to tag the user's interests but does not offer any tagging for the learning resources, courses or sub-courses.

3.5 Summary

The background research described within this chapter has provided an understanding of the current body of knowledge relative to learning tools, e-learning and authoring for online content, which is required for the aims and objectives of this project.

This research has shown that there are many different types of authoring tools available. It was found that general authoring tools are not flexible or adaptable enough for current learners as they are limited and do not offer the functionality that learner's are becoming familiar for example, functionality within current e-learning platforms.

It was found that many adaptive hypermedia systems have been developed offering a variety of functionality. However, the research demonstrates that issues with these include flexibility, reuse and integration problems due to the nature of the architecture. Due to these reasons these adaptive systems are not widely used today and often exist for research purposes.

Issues were also found with the adaptive systems that incorporate learning styles and Brusilovsky and Millán (2007) highlight some of these. They state that there is no proven recipe for the application of learning styles and that they are also unclear what is worth modelling. They, therefore, state that it is necessary to develop other techniques for the adaption. These systems are not widely used today and one reason for this is that the functionality offered is inflexible.

According to Costello et al. (2009), personalised learning means high quality teaching that is responsive to the different ways that students can achieve their best results. The research has shown that researchers suggest that the web can offer the ideal environment for individualised learning due to its nature. However, even though research has shown that personalised learning is important, the evaluation within this chapter has shown that current e-learning platforms do not offer a personalised adaptable environment for the learner.

The e-learning platform evaluation undertaken and described within this chapter has shown that common popular e-learning platforms have a variety of tools available for the instructor and learner including assessment management and forums. However, it was found that none of the platforms evaluated during the study offer a personalised learning experience for the learner, most personalisation offered is interface personalisation rather than personalised or adaptive content.

During the research, the technical review led to an investigation into tagging. This research demonstrated that tagging, although currently popular with users on the web and particularly in social media, is not widely used within e-learning. Research has shown, however, that tagging could be beneficial to e-learning and in particular it is felt that it could be a useful tool for offering personalised and adaptable learning for a learner.

Many standards (LOM and SCORM for example) have been developed within tagging and e-learning for learning objects, metadata and it is felt that these are important to be incorporated into systems to promote reusability of learning objects and material. It was also found during this research that reusing learning objects and learning material could be a good starting point for incorporating personalisation within a system.

The research discussed within this chapter therefore completes the first aim of "to understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles" as this chapter discusses personalised and adaptive learning techniques and e-learning tools.

It also completes the first objective of "to carryout a critical and comprehensive review of research within the area of e-learning tools, personalised and adaptive learning, and learning styles" as e-learning tools, personalised and adaptive learning are critically reviewed. The research within this chapter also describes work for the objective defined in Chapter 2, which is to investigate adaptive systems incorporating learning styles. The second objective of "to investigate current trends and technologies within e-learning" is also satisfied as current technologies including the semantic web and tagging are discussed within the research.

The project objective of "to carry out an evaluation of the personalisation and adaptability offered by e-learning platforms" that was highlighted during the research work was also completed within this chapter.

Due to the research findings relating to tagging and adaptive systems, it is felt that this demonstrates that the hypothesis "a mechanism can be developed to personalise learning materials to an individual learner according to their learning style" would be improved if the proposed mechanism were a tagging model that will provide personalisation within the context of a hypermedia system.

Therefore based on the research within this chapter, the hypothesis was changed to, "a tagging methodology can be developed to personalise learning materials to an individual learner according to their learning style". This methodology is discriminatory, as it will enable discrimination between learners based on their specific individual needs.

The term "methodology" is used here as defined by Avison and Fitzgerald (1995), which is "a collection of procedures, techniques, tools and documentation aids, which will help the systems developers in their efforts to implement a new information system".

This tagging methodology will be required to adhere to standards, where possible, to offer personalised learning addressing issues found with other adaptive systems incorporating learning styles described within this chapter.

4 Design of a methodology for tagging learning objects for personalisation and reuse

4.1 Introduction

The outcome of the research described in the previous chapters identified that there is a lack of a tagging methodology within the context of an adaptive hypermedia e-learning system that will enable learning and assessment object personalisation and reuse. This methodology to be developed corresponds to the project objective of developing a tagging system for tagging learning and assessment objects for personalisation and reuse. The author published the tagging methodology designs described within this chapter in 2010 and 2011 (see Peter et al. (2010) and Peter et al. (2011)).

The research has also shown that generally tagging within e-learning is currently underused and there are obvious benefits to using tagging within e-learning for personalisation and adaptability. Tagging is growing in popularity on the web and therefore it is felt that it would be a beneficial advantage to an e-learning environment. In particular, it is felt that tagging learning material could allow for authoring personalised learning objects for a learner.

Adaptive hypermedia systems incorporating learning styles are not commonly currently used and research has shown that this is because they are limited in function and lack flexibility. These systems tend to be developed for research purposes only at present and are not offering traditional e-learning functionality for the instructor and learner.

A learning object authoring and discriminatory tagging methodology was therefore developed during this research to address these issues. Two examples of the discrimination methodology described within this chapter are learning styles and accessibility. This methodology was designed to be adaptable and to work with many possible implementation environments.

The tagging design for the methodology is described in detail in this chapter including an overview of the methodology, the learning material tagging and metadata design, the learning style representation within the system, the learner profile and finally the personalised learning package. Then within the final section of the chapter an overview of the methodology steps are described, giving an example of how the methodology would be used for accessibility discrimination.

The outcome of the learning style research described in Chapter 2 was to choose Flemings VARK as the learning style for part of the personalisation offered and therefore this was chosen for the first example of this tagging methodology.

The methodology will allow the instructor to add a number of tags for the learning and assessment objects. These objects can then be provided to the learner based on a number of user specific requirements including the learner's learning style.

Within the methodology, it is possible for the instructor to tag learning objects so that the learner can search and view files corresponding to their own discrimination type (for example their learning style type). The learner is also able to search and view all objects and is therefore not just restricted to objects specific to their discrimination type. Once objects have been viewed and selected for the learner, a personalised learning package will be able to be created for the learner based on their own requirements.

4.2 Overview of the authoring and tagging methodology

This developed metadata tagging methodology is designed for an instructor to author objects to allow for personalisation and reuse and to enable the learner to search the tagged learning material to provide content for their own personalised learning space.

The learning material used within this methodology has been defined as learning and assessment objects. Different types of material for these objects have been defined within the methodology and these will be described later on in detail within this chapter.

The tagging methodology will allow for the instructor to author and tag the learning objects with metadata so that the learner can control how the learning object is used and represented. Tagging the learning objects this way will allow for the content of a learning object to be consistently represented within an appropriate e-learning platform or within another e-learning system.

The following section of the report gives an overview of the instructor authoring incorporating tagging and the learner part of the methodology.

4.2.1 Overview of instructor authoring incorporating tagging

The methodology is designed to incorporate learning and assessment object tagging for the instructor. The methodology has therefore been designed for an instructor to be able to author and tag learning content within an e-learning environment.

As an overview, it was decided that this methodology allows for the instructor to tag learning and assessment objects in a number of ways including:

- Tagging to classify the learning object content:

  The instructor can create and select subject and topic groups within a hierarchy for the content. Within the tag set, a subject may have several topics associated with it. The subject and topic groups are domain specific and can be created by the instructor.

- Add tags to add relationships between the learning and assessment objects:

  The subject, topic and learning object groups are groups of learning and assessment objects and therefore these objects are related together within their group. The grouping can be tracked according to their learning object group.

- Tags that can relate the learning or assessment material to the level of an individual learner's knowledge:

  The instructor can tag the learning and assessment objects with the object's specific learning content level, which can then in turn correspond to an individual's knowledge. The instructor will decide on the suitable level and this level can vary according to requirements.

- Tags that create an assessment grouping for subject groups, topic groups and learning object groups:

  A tagged assessment object may be added at each level, including the subject level, the topic level and the learning object group level.

These tags will enable the learning and assessment objects to be stored with metadata tags that will then be available to provide the learner with learning content suitable for their specific needs. They cover a range of concepts, which enables the learner to be able to search for learning objects that suit their requirements.

4.2.2 Overview of the learner part of the methodology:

The learner side of this methodology is designed so that the learner can search and select appropriate learning and assessment objects based on their own specific requirements, including:

- The discrimination type example: learner's learning style preferences:

  The learner selects objects based on the Fleming's VARK learning style file type preferences. The learner has the opportunity to identify their learning style by completing the VARK questionnaire online. The learner's learning style type will be stored within the learner profile. This learning style representation will be discussed later in this chapter.

- Learner knowledge level:

  The learner adds their current knowledge skill level requirements to their search criteria and learner profile.

- Specific subject and topic group preferences.

  The learner can browse the subject and topic groups and make a selection according to their own requirements.

- The learner can select and view and browse all available objects together with objects specifically based on their own requirements.

  The selected objects can then become part of the learner's personalised learning package that will be specific to their needs.

4.3 Learning material tagging design

4.3.1 OWL and RDF Design

Initially the tagging design and metadata was designed in OWL using the Protégé software developed by Stanford University.

The classes and rules were defined and figure 6 shows some of the classes defined within Protégé.

The semantic rules for the learning style categories were then created within Protégé and are described as follows:

- Aural type has prefersFileType only AudioFile and PPSlideFile and PodcastFile.

- Kinesthetic has prefersFileType only MultimediaFile.

- Multimodal has prefersFileType only AudioFile and MultimediaFile and PPSlideFile and PodcastFile and TextMaterialFile and VideoFile.

- ReadWrite has prefersFileType only PPSlideFile and TextMaterialFile

- Visual has prefersFileType only PPSlideFile and PodcastFile and Video

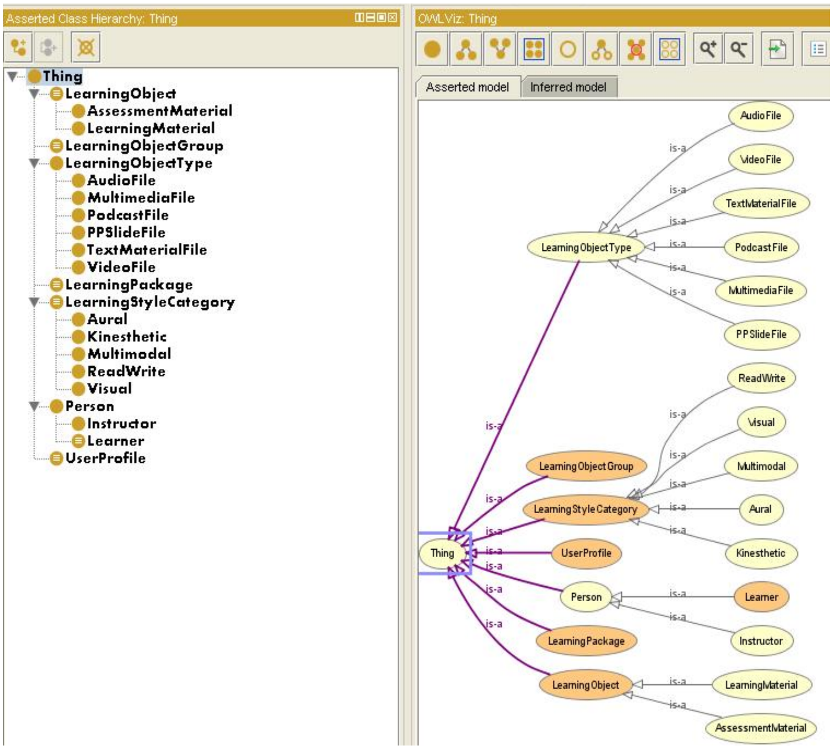


Figure 6: Classes and subclasses in protege

Designing the classes and rules within Protégé was found to be a really useful exercise as it supported the development of clear semantic rules for use in the tagging methodology.

The outcome of some research into the semantic web technologies was that it was felt that however powerful and promising the concept of the semantic web is, the current available tools and technologies are fairly limited at the moment. In particular, issues were found with the interface and usability using this technology. Additionally, students learning within e-learning environments now expect a level of functionality that would be very complex to develop using the semantic web technologies.

4.3.2 The XML tags design

Next, it was decided to design the tags in XML and develop an extension the SCORM model (as described in Chapter 3) in which an external XML document is referenced. An example of this XML is shown in Figure 7 as follows:

```xml
<LearningObjectGroup>
   <topic>Validation</topic>

      <objects>
        <LearningObjects>
               <LearningObject>
                 <Type>Lecture Notes</Type>
                 <FileType>PPSlides </FileType>
                 <Description>Lecture notes about c# validation</Description>
                 <Level>Introductory</Level>
               </LearningObject>

               <LearningObject>
                 <Type>Instruction video</Type>
                 <FileType>Video</FileType>
                 <Description>asp.net validation video</Description>
                 <Level>Introductory</Level>
               </LearningObject>

               <LearningObject>
                 <Type>Tutorial Exercise</Type>
                 <FileType>HTML</FileType>
                 <Description>c# programming tutorial exercises</Description>
                 <Level>Introductory</Level>
               </LearningObject>
       </LearningObjects>

        <AssessmentObjects>
               <AssessmentObject>
                 <AssessmentType>Test</AssessmentType>
                 <FileType>Flash</FileType>
                 <Description>Basic asp.net validation quiz</Description>
                 <Level>Introductory</Level>
               </AssessmentObject>

               <AssessmentObject>
                 <AssessmentType>Test</AssessmentType>
                 <FileType>Word</FileType>
                 <Description>Basic asp.net programming test</Description>
                 <Level>Introductory</Level>
               </AssessmentObject>
       </AssessmentObjects>
  </objects>
</LearningObjectGroup>
```

Figure 7: Snippet of example XML code

The XML tags describe the learning object groups and tags for the learning and assessment objects. Tags for the learning objects are defined as type, file type, description and level. Tags for the assessment objects are defined as assessment type, file type, description and level.

Schemas were also defined within the methodology and an example schema defining a learning object group in the learning object group is shown in Figure 8.

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema attributeFormDefault="unqualified" elementFormDefault="qualified" xmln
  <xs:element name="LearningObjectGroup">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="topic" type="xs:string" />
        <xs:element name="objects">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="LearningObjects">
                <xs:complexType>
                  <xs:sequence>
                    <xs:element maxOccurs="unbounded" name="LearningObject">
                      <xs:complexType>
                        <xs:sequence>
                          <xs:element name="Type" type="xs:string" />
                          <xs:element name="FileType" type="xs:string" />
                          <xs:element name="Description" type="xs:string" />
                          <xs:element name="Level" type="xs:string" />
                        </xs:sequence>
                      </xs:complexType>
                    </xs:element>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
```

Figure 8: A code snippet of the XML schema

This XML was developed and incorporated into an initial early prototype system created using asp.net and the C# programming language. This prototype allowed for the tags to be tested within a programming environment. However, it was found that it was fairly limiting, as the functionality created could not match the current functionality offered by current popular e-learning platforms without several person years of effort. Learners and instructors expect a certain level of functionality that is provided by current popular e-learning platforms and this would not be realistic to replicate.

The outcome of this prototype development and the semantic web technology evaluation was to choose to extend a current e-learning platform to incorporate the tagging. It was felt that this way the tag set design could be built on top of the functionality offered by these platforms, which would be beneficial for both the instructors and learners.

4.3.3 Metadata design

During the design process, it was felt that the objects had to be as flexible as possible by having metadata to describe various properties, including their group, their topic and the subject level.

The system will hold the data and metadata (data about that data) tags within a container. The metadata will be arranged in a generic format, which will allow for an effective personalised search and manipulation of the data.

The metadata is designed to adhere to standards where possible, including using the IEEE Learning Object Metadata (LOM) standard where possible.

The main issues considered when designing the objects metadata were the subject and topic hierarchy, the object file type, the resource type and the knowledge level for the object. These tags will now be described in more detail within this section.

4.3.3.1 The subject and topic hierarchy

An ontology hierarchy of subjects and topics has been defined for the system. The hierarchy will have subjects, topics, and corresponding learning object groups containing the learning and assessment objects.

This hierarchy is not fixed could be expanded and extended for other subject and topic groups as required and it could also incorporate different levels of hierarchy. This hierarchy will be dependent on the subject domain and requirements.

An example of a hierarchy is that a subject (for example asp.net) will contain a number of topics (for example introduction web forms) which will contain a number of learning object groups (for example validation). Figure 9 shows this subject and topics hierarchy example in more detail showing the learning and assessment objects from the example domain of computer programming.

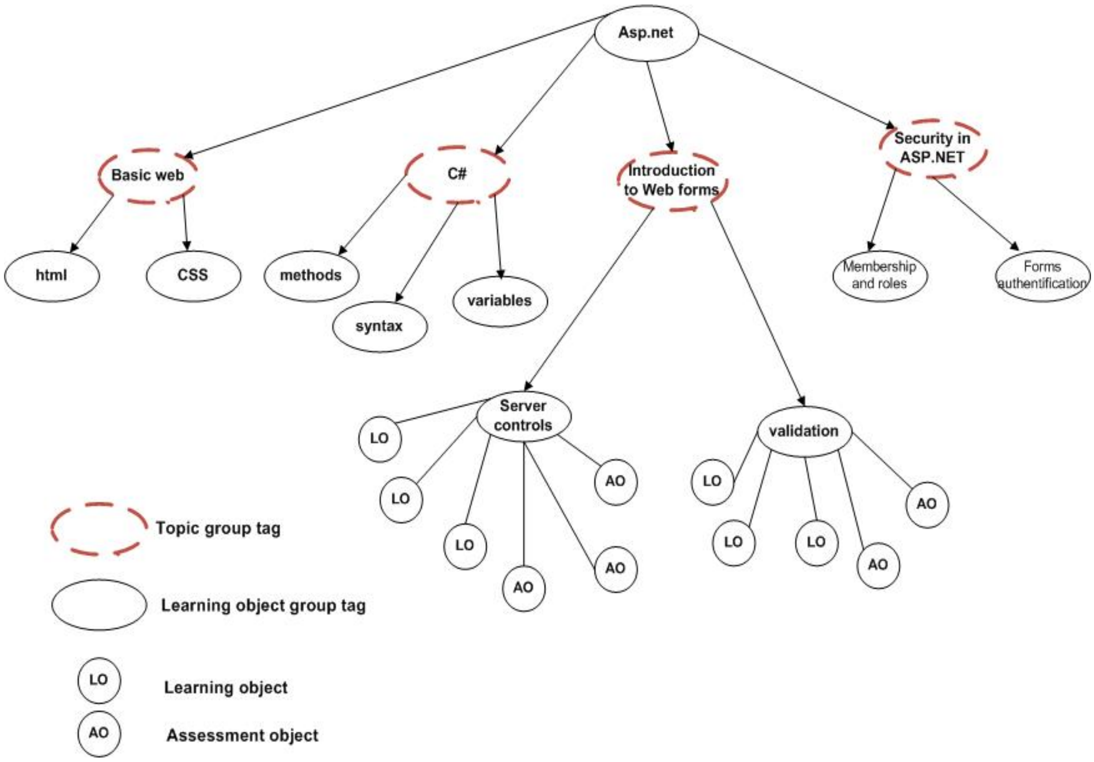


Figure 9: Example subject, topic and LOG hierarchy

The example in Figure 10 shows in more detail an example of topic and learning object groups. It shows asp.net as the subject, as example topic group as introduction to web forms and an example object group as validation.

This introduction to web forms topic group is shown in detail in figure 10. This demonstrates two of the learning object groups for the topic tag which are validation and server controls. It shows that the learning object groups can have a number of learning objects and assessment objects associated with it. For example the validation learning object group has three learning objects and two assessment objects associated with it.

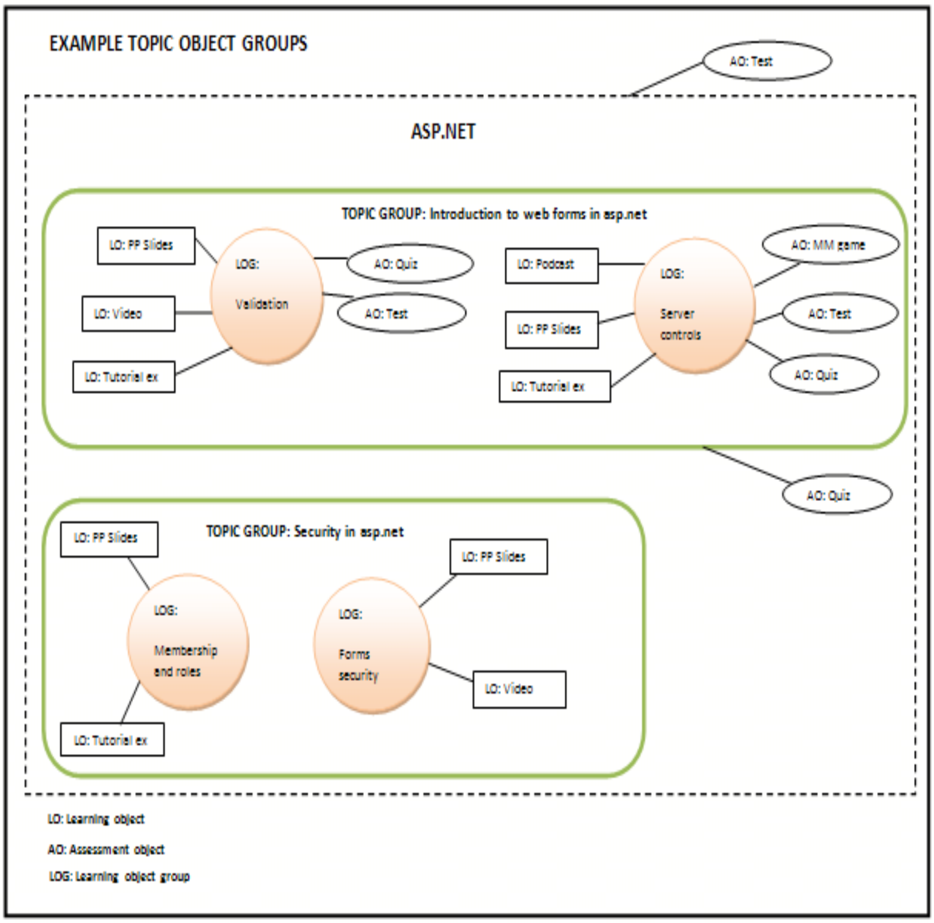


Figure 10: Topic groups and learning object groups

The methodology also allows for assessment to be associated with each level (i.e. at the subject, topic or learning object group levels). The example shown in Figure 10 has a test assessment at the subject level (ASP.NET), a quiz assessment at the topic level (Introduction to web form in ASP.NET) and a number of test assessments at the learning object group level (e.g. the LOG validation has two assessments associated with it – one quiz and one test).

4.3.3.2 Description metadata

The IEEE Learning Object Metadata (LOM) Description metadata is used as the description metadata for the methodology. It was felt that it was important to ensure that the system was adhering to standards and the IEEE LOM Description seemed appropriate to use in this case because it is the standard for describing a learning object. LOM describes this as a textual description of the content of this learning object. LOM definition states “the description should be in language and terms appropriate for those that decide whether or not the learning object being described is appropriate and relevant for the users”. An example of a description for a video clip given by LOM is "In this video clip, the life and works of Leonardo da Vinci are briefly presented. The focus is on his artistic production, most notably the Mona Lisa”.

An example description for the asp.net example could be “asp.net lecture notes covering the web forms topic”.

4.3.3.3 Keyword metadata

The IEEE Learning Object Metadata (LOM) Keyword is used for the definition for the keyword metadata within the methodology. LOM describes this metadata as a keyword or phrase describing the topic of this learning object. The example that the LOM definition gives relating to the video example is “Mona Lisa”.

An example keyword metadata for the asp.net example could be “asp.net, web forms”

4.3.3.4 Learning material file type metadata

The learning material file type metadata tags proposed will include common learning material file types which are PowerPoint slides (with audio), text files, audio files, podcast, vodcast, multimedia and PowerPoint slides (without audio). They can be extended to other types as required.

Enabling the instructor to tag the learning object with the file type will allow for the learner to be provided with learning material based on their specific learning style requirements. The learning style representation is described in more detail later on in this chapter.

4.3.3.5 Learning material resource type metadata

The IEEE Learning Object Metadata (LOM) Resource Type is used within the methodology to define the resource type. The LOM explanation for this is that it is a specific kind of learning object and that the dominant kind shall be first.

Therefore, a tag can be added for the objects to categorise them into one of the specified resource types, which are Lecture, Exercise, Simulation, Questionnaire, Diagram, Figure, Graph, Index, Slide, Table, Narrative text, Exam, Experiment, Problem Assessment and Self Assessment.

These can be divided into learning and assessment objects for example:

Learning objects: Lecture, Exercise, Simulation, Narrative text, Experiment

Assessment objects: Exam, Problem Assessment and Self Assessment

Together with the file type, the resource type is also used within the system to provide objects to the learner based on the learning style type. This learning style representation is described in more detail later on in this chapter.

4.3.3.6 Knowledge level metadata

To represent the knowledge level of the object, it was also decided to use the IEEE LOM standard difficulty metadata type.

The LOM definition states that this type specifies how hard it is to work with or through this learning object for the target audience (which in this case will be the learner). The tag selections for this category are very easy, easy, medium, difficult and very difficult.

It was thought, however, that as the IEEE LOM standard difficult metadata type was making real generalisations there was a need to categorise these further and so therefore, the learning objects are also tagged according to whether the object is for 1st year undergraduate students, 2nd year undergraduate students, 3rd year undergraduate students and Masters level students. This could be changed, however, to represent the student cohorts within a given system.

The instructor will therefore have to decide which category the learning object will fall under, as it will depend on the subject domain and also the corresponding undergraduate or Masters level.

4.4 The learning style representation

The outcome of the research undertaken into learning styles and their suitability for personalisation and adaptability was to choose Fleming's VARK as the most suitable model. This research is described in Chapter 2 Section 2.4. The main reason for choosing this learning style model is that the model has a concise questionnaire available for the learner to complete and additionally, it is felt that the learning and assessment objects can clearly map to the VARK learning style categories.

The VARK learning style model has an online questionnaire containing 16 questions. Figure 11 shows an example of the questions in the questionnaire. Within the implemented system, the learner will have the opportunity to complete the online questionnaire and after completing the questionnaire the learner will be provided with their VARK learning style score.

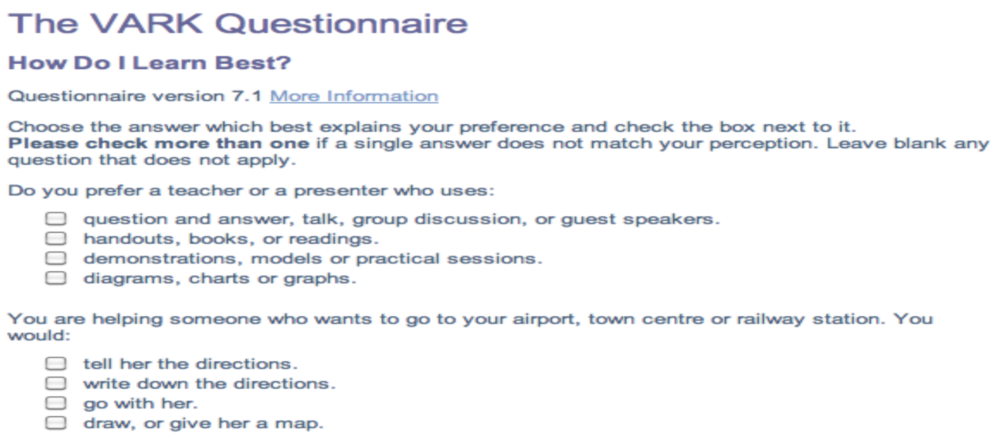


Figure 11: Sample questions for the VARK online questionnaire

The scores will be a combination of Visual, Aural, Read/Write and Kinesthetic and a learner may have a learning style type of any combination of these or may have a learning style type of one stronger learning style category. Once the learner has completed the questionnaire, the learner can add their learning style to the system though this could be updated as required. Figure 12 shows the questionnaire results multimodal (VARK) type of learner. This learning style type will be stored in the learner profile.

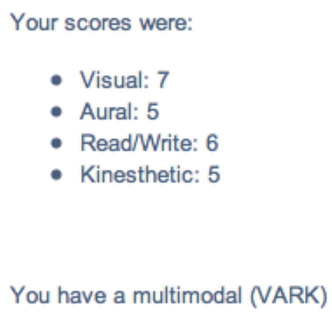


Figure 12: Multimodal (VARK) type of learner

The learning style object mapping for the tagging will now be described in more detail.

Two types of object mapping exist within the tag set. One mapping type is the file type and the other mapping type is the resource type.

Table 4 describes how the file type maps to the learning style, for example the Visual type may prefer to view Text, Vodcast or PowerPoint file types. Figure 13 also shows the file type object mapping.

The other mapping type is the LOM resource type, (also shown is Table 4) for example, someone who has a Visual type may prefer diagrams, figures and graphs resource types. Figure 14 shows the resource type object mappings. As a learner may have any combination of VARK learning style categories, this may include a multimodal learning type that covers a mix of all style categories. This includes any combination of learning style categories. For example, someone may have the multimodal learning style type RK and they may prefer the following:

File type preferences:

PowerPoint Slides (R) and text documents (R) and multimedia interactivity (K)

Resource type preferences:

Lecture (R) and Narrative text (R) and Exercise (R) and Index (R) and Questionnaire (R) and Slide (R) and Table (R) and Exam (R) and Simulation (K) and Experiment (K) and Problem assessment (K)

VARK Learning Style	Fleming recommendations of study strategies	Example learning objects	LOM resource type
Visual	Pictures, video, posters, slides, flowcharts, graphs, diagrams	Text, vodcast, Powerpoint sides	Diagram, figure, graph
Aural	Discuss topics and ideas, remember stories, jokes etc.	Powerpoint slides (with audio), multimedia, podcast	Lecture, simulation
Read/write	Lists, headings, dictionaries, definitions, text, books, manuals	Powerpoint slides, text documents	Lecture, narrative text, exercise, index, questionnaire, slide, table, exam
Kinesthetic	Doing things, practical, real relevant	Multimedia activity	Simulation, experiment, problem assessment
Multimodal	Mix of the above learning styles, learning objects and LOM resource type		

Table 4: VARK learning style and object mapping representation

There is some overlap for the file type preferences and the resource type preferences and these overlaps are shown in Figure 13 and Figure 14.

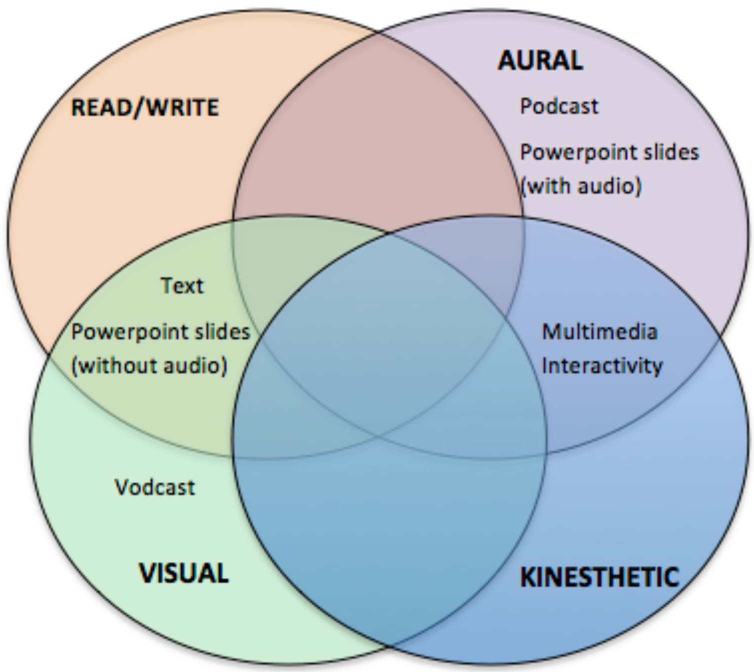


Figure 13: Learning style: learning file type diagram showing overlap

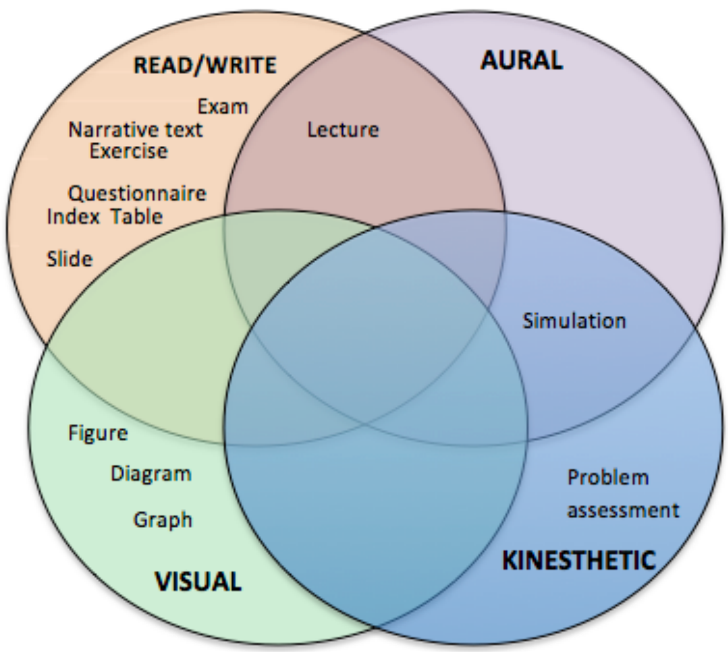


Figure 14: Learning style: learning resource types diagram showing overlap

4.5 The learner profile

The learner profile corresponds with the user model as defined by Brusilovsky (2007). This model is one that contains all of the data about the learner. The system will use the information in the learner profile to adapt learning content to suit the learner's needs.

The learner profile contains information about the user's knowledge of the topic or subject domain, the users goals, background and individual traits, all of which Brusilovsky (2007) states are important features for user models in an adaptive system. Figure 15 gives an overview of the information that is held in the learner profile.

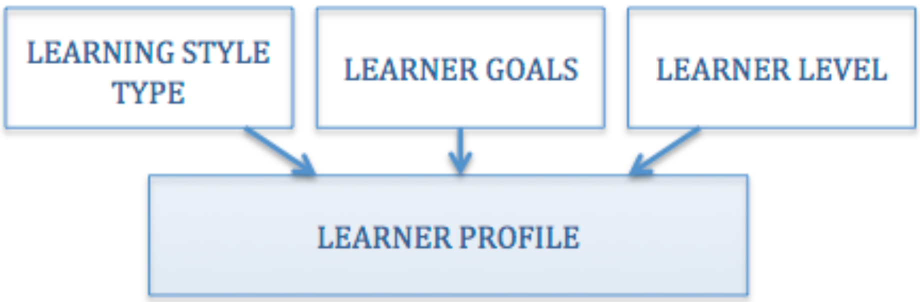


Figure 15: The learner profile

Each section of the learner profile will now be described in more detail.

The learning style type

This is the learning style category based on the VARK learning style as described earlier in this chapter. The learner may be Visual, Aural, Read/Write, Kinesthetic or any combination of those categories. The learning style will be stored within the learner profile but can be updated by the learner when necessary.

Learner goals

Specifically, what subject area and topics does the learner actually want to learn according to a specified domain containing subjects, topics and learning object groupings.

Learner level

What level of knowledge does the learner have for a particular subject or topic. The learner level will correspond to their year of study (designed for higher education here, however, this could change depending on domain) and whether they have any experience within the subject or topic.

The system will use this information about the learner to adapt to their specific needs. Additionally, the learner can update all of the learner profile information if required.

4.6 The personalised learning package

The learner will be able to search for the learning and assessment objects based on their own requirements to create their own personalised learning package. Their requirements could be to search all learning material for the subject/topics or search for material for their learning style, knowledge and level requirements.

Once the learner has searched for learning and assessment objects based on their own requirements, they can select the learning and assessment objects that they require. Learners can also search all of the learning and assessment objects not just the objects suitable for their learning style.

The searchable learning objects may come from different learning object groups and will be packaged with other objects selected by the learner to create their own learning environment as a personalised learning package.

Figure 16 shows the personalised learning package concept in more detail. This figure shows four learning object groups (LOG's) and two learners both with their own unique personalised learning packages. These unique learning packages can contain some of the same learning and assessment objects from the same learning object groups.

For example both of the learners personalised learning packages in Figure 16 have some learning and assessment objects from LOG 1,3,4. Learner 1 has objects from all LOG groups while Learner 2 has objects from all groups except for LOG2. The learners also share some of the same learning and assessment objects.

The learner will be able to search for the learning and assessment objects based on their own requirements to create their own personalised learning package. Their requirements could be to search all learning material for the subject/topics or search for material for their learning style, knowledge and level requirements.

This personalised learning package will allow the learner to take control of his or her own learning. This directly corresponds to the heutagogy learning approach in which the teacher provides the resources but the learner designs the actual course he or she might take by negotiating the learning materials (Hase and Kenyon 2001). The personalised learning package will enable the learner to structure and manage his or her own learning.

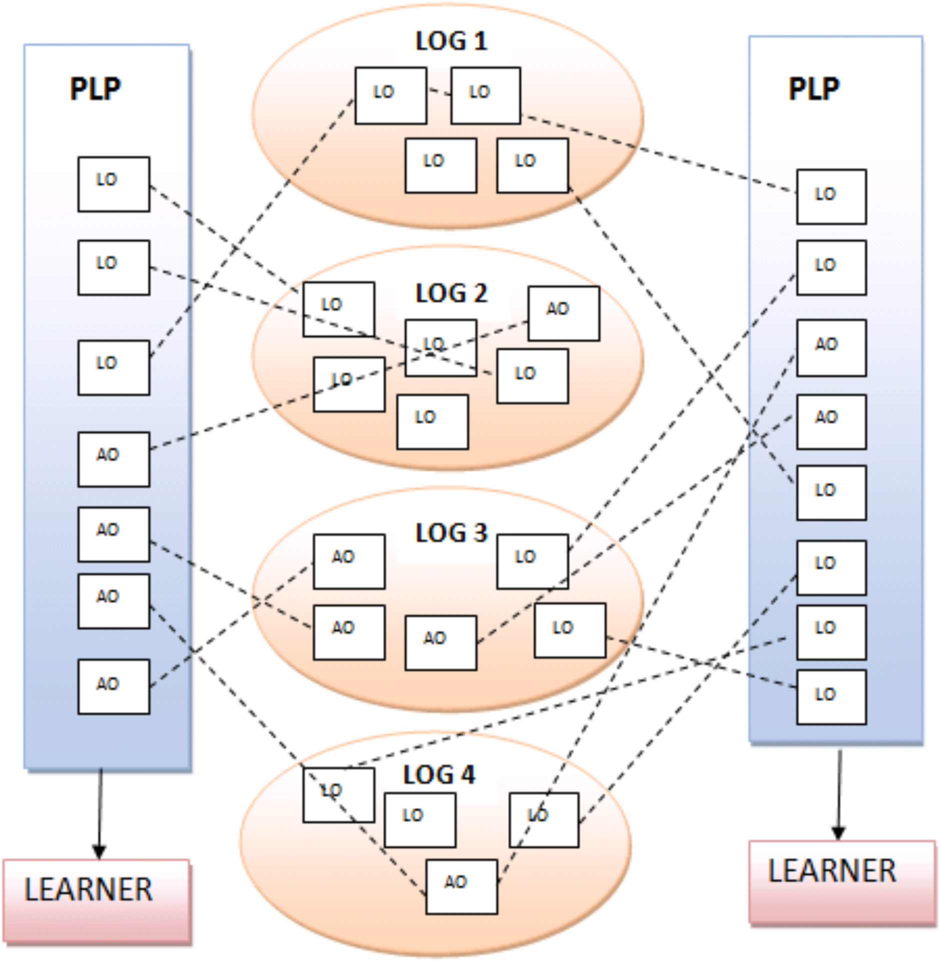


Figure 16: View of the personalised learning package

4.7 The methodology overview demonstration incorporating another discriminatory tagging example

The background research describes the benefits of personalised and adaptive learning, and discriminatory models offer a way to personalise and adapt learning material to a learner, according to their discriminatory type. Learning Styles are described earlier in this chapter, and represent one example of a discriminatory model. However there are numerous possibilities for other discriminatory models, for example models based on religious, cultural or accessibility discrimination. The methodology described within this chapter is therefore a mechanism to achieve personalised and adaptable learning, and is flexible enough to incorporate a number of different discriminatory models. The methodology described within this chapter is novel in the use and application of discriminatory models, and provides a number of steps that need to be completed to achieve this as shown in Figure 17.

Currently the IEEE LOM only discriminates in terms of complexity (i.e. the level of difficulty of the learning object) and they don't allow for any other type of tagging for discrimination. The metadata models (e.g. IEEE LOM) are promoting the same standard metadata but the argument against using these models are that we are not all the same and the standards will not fit all requirements. Whereas within this methodology there is no limit to the amount of tags or discrimination types and so therefore this offers lots of flexibility unlike the standard metadata models. There is lots of flexibility within this methodological approach as the instructor is offered autonomy and freedom from standardised constraints, at the cost of heterogeneity, which will increase the processing requirement.

The discriminatory tags devised within the methodology are combined with the IEEE LOM tags (with additional elements for level) and subject/topic hierarchy tags as described earlier within this chapter. The distinction between the IEEE LOM tags and the discriminatory tags are that the IEEE LOM would allow the learning objects to be searchable by level and content only (similar to the standard metadata search within repositories such as Jorum), whereas the discriminatory tags allow the learning objects to be searchable by the attributes of the discriminatory model.

Based on the research carried out for this thesis, no existing systems have been found that offer the discriminatory tagging capability that has been developed and described herein. The methodology described within this chapter covers the steps that need to be completed to provide the discriminatory tagging capability, and they are shown in Figure 17.

The first step in the methodology is to define the type of discrimination required. Next, the semantic rules, the xml schema and the tag set need to be created for the discrimination. Then the final part of the methodology is the implementation stage.

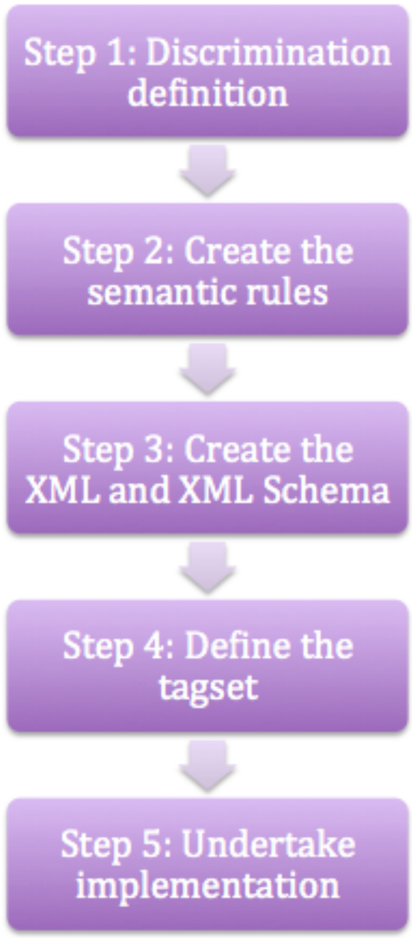


Figure 17: Discriminatory methodology steps

Here follows a work through of the methodology steps for another example of discriminatory tagging which is tagging for accessibility. This work through will show how and why the steps are performed for the tagging methodology.

Step 1: The discriminatory tagging definition process

At this stage in the process the required discrimination may already have defined characteristics, or they may need to be defined. An instructor would complete this step and so therefore the tagging definition would be down to the discretion of the particular instructor. Any discriminatory system can be devised and multiple tags for different discrimination types can be associated with a particular learning object.

The instructor would therefore need to decide on the type of discrimination and how this could be modelled for the discrimination tags. They would need to decide on the tags and possible tag content at this stage.

The previous discrimination example demonstrated within this chapter was the VARK learning style, and the further example described within this section uses accessibility as the discrimination type. For the accessibility discrimination type it was decided that types of accessibility to be modelled for this discrimination example are visual, hearing, cognitive or movement disability as these categories generally cover the main types of disabilities. It was felt that this selection covers most disability types.

Within the learning style example described earlier within this chapter, the VARK learning style mapped clearly to the file types, however it was found that accessibility does not map so well. It is felt that visual and hearing disabilities can map well to file types but cognitive and movement disabilities do not. With this in mind, for this example, the instructor uploading the object will have to make the decision about which tag is appropriate at the time of association so they will therefore need to make a choice accordingly. Due to this, the schema will contain the reusable tags for this purpose and the system can contain advice for the instructor about which tags would be suitable for which disability type.

An example of a possible accessibility discrimination definition defined at this stage therefore is the definition of a categorisation of tags for hearing, visual and accessibility options. The instructor therefore would make the decision when uploading the file about which learning object is suitable for each accessibility type.

Step 2: Create the semantic rules for the discrimination

The outcome of the research undertaken into the semantic web and Protégé described within this thesis found that available semantic web tools and techniques are not currently sufficiently mature or robust to support the methodology, therefore xml was chosen as the technology for the methodology. However it was decided that semantic rules should be defined within this methodology, to allow for better semantic linking between objects within models and to enable the objects to be incorporated into semantic tools when the tools become more mature and available.

The semantic rules define the tags and possible tag content and also whether one or more tags can be used per category within the discrimination.

With this in mind, the semantic rules for the discrimination need to be defined in this step of the methodology. This section describes the semantic rules for the accessibility discrimination example as defined in the previous step as hearing, visual and accessibility option categories of tags.

The file types tag for visual and hearing disability semantic rule is defining a selection choice of one (shown in this statement as only):

- `Visual type has prefersFileType only AudioFile and PPSlideFile (with audio) and PodcastFile (with description) and MultimediaFile (with description).`
- `Hearing has prefersFileType only PPSlideFile (without audio) and VodcastFile (with transcript) and MultimediaFile (with transcript).`

The accessibility option tags semantic rule is defining a selection of more than one (shown in this statement as some):

- `AccessiblityOption has prefersAccessibilityOption some KeyPress and AlternateInput and VoiceRecognition and Description and Transcript`

These rules could be defined within Protégé (as described in section 4.3.1), however until the semantic technologies are more developed, a more simple rule definition as described above is all that is required. This simple rule definition is describing the selection choice of the tag (whether only one or more is allowed). The rules will be implemented into the system incorporating the tagging and they will be available for future use by semantic technologies.

Step 3: Create the xml and xml schema for the discrimination

The next stage is to create the xml and xml schema (xsd) for the discrimination. The xml document defines the tag mark-up declarations for the tags and the schema defines the elements and attributes, the structure of the xml document and the data types for the elements.

Following on from the previous step, an example of an xml document for the accessibility discrimination example defined within this section is shown in Figure 18. This document shows the tags as xml elements and can be created in any xml editor.

```xml
<?xml version="1.0" encoding="utf-8" ?>
<LearningObjectGroup>
  <topic>validation</topic>
  <objects>
    <learningObjects>
      <learningObject>
        <type>Lecture Notes</type>
        <FileType>PPSlides(with audio)</FileType>
        <Description>Lecture notes about validation</Description>
        <Level>1st year undergraduate</Level>
        <AccessibilityOption>Description</AccessibilityOption>
      </learningObject>
      <learningObject>
        <type>Instruction video</type>
        <FileType>Vodcast (with transcript)</FileType>
        <Description>asp.net video</Description>
        <Level>1st year undergraduate</Level>
        <AccessibilityOption>Transcript</AccessibilityOption>
      </learningObject>
    </learningObjects>
  </objects>
</LearningObjectGroup>
```

Figure 18: XML showing tagging for accessibility

This xml document shows the xml mark-up for the standard LOM IEEE tags as defined earlier within this chapter and also the tags associated with the accessibility discrimination as defined in the previous stage. The discrimination tags are associated with the learning objects together with the LOM IEEE tags to enable the object to be searched by content and level as well as being searched according to the discrimination attributes.

The xml document also shows that the learning objects can have a different file type (Vodcast (with transcript)) within the FileType tag and also shows the

AccessibilityOption tag to enable the accessibility discrimination for the learning objects. Creating this xml tagging ensures that the content of a learning object will be consistently represented within whatever environment it is delivered in.

The xsd is created next and this provides the tag set definition by which to mark-up the learning objects. The xsd is portable and so other instructors can use the same one, create a new one or re-use an existing one. Unlike the metadata model, which is a standard (e.g. Dublin Core) and which is pre-defined and inflexible, the xsd provides greater freedom for the instructors The xsd can therefore be provided to a community of instructors or authors to enable standardised tagging, in a similar way to the metadata models, but using the xsd instead of the metadata model allows the instructors to be able to extend and vary their tag sets. Allowing users to create their own xsds can create semantic issues, particularly semantic heterogeneity, however using techniques such as the global semantic mapping as used by the database community can help to handle the complexity and create an ontology of terms.

The xsd for the accessibility discrimination example is shown in Figure 19. The schema can be created using any xml editor. This schema shown in Figure 19 incorporates the accessibility option tag.

The schema defines the tags declaration as xs:elements, the structure of the xml document (showing nesting, for example the tag elements are nested within the learning object element) and the data types for the elements (for example the datatype for the FileType tag is xs:string).

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema attributeFormDefault="unqualified" elementFormDefault="qualified" xmlns:xs="http:/
  <xs:element name="LearningObjectGroup">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="topic" type="xs:string" />
        <xs:element name="objects">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="learningObjects">
                <xs:complexType>
                  <xs:sequence>
                    <xs:element maxOccurs="unbounded" name="learningObject">
                      <xs:complexType>
                        <xs:sequence>
                          <xs:element name="type" type="xs:string" />
                          <xs:element name="FileType" type="xs:string" />
                          <xs:element name="Description" type="xs:string" />
                          <xs:element name="Level" type="xs:string" />
                          <xs:element name="AccessibilityOption" type="xs:string" />
                        </xs:sequence>
                      </xs:complexType>
                    </xs:element>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
            </xs:sequence>
```

Figure 19: XML schema for accessibility

After creating the xml document and xsd the next step is to design the tag set for the implementation.

Step 4: Define the tag set specification for the discrimination

The next step is to define the tag set for the implementation. Table 5 shows the possible tag set for the accessibility discrimination including tags for vision, hearing and accessibility options. The instructor would need to make the decision about the possible tags available in the tag set. As this is down to the discretion of the instructor, this is where issues with the semantics of tags can come in. Instructors may use different terms but have the same meaning, therefore someone would have to be given authority to make the decision on the tags.

Table 5 shows that the Vision_disability tag has possible tags for additional file types of multimedia (with descriptions) and vodcast (with descriptions) and the Hearing_disability tag has possible tags for additional file types of multimedia (with transcript) and vodcast (with transcript). These are the straight file type mappings that can be added for the disability types. Table 5 also shows the Accessibility_option tag with possible tag content including Key_press, alternate_input, voice_recognition, speak_text, description and transcript. This list is not necessarily complete and more possible tags can be added where necessary.

Tag	Possible values
Vision_disability	PowerPoint (with audio), podcast, multimedia (with descriptions), vodcast (with descriptions)
Hearing_disability	Text, PowerPoint (without audio), vodcast (with transcript), multimedia (with transcript)
Accessbility_option	Key_press, alternate_input, voice_recognition, speak_text, description and transcript

Table 5: Tag set for the accessibility example

During the implementation, this tag set will be added together with the IEEE LOM tags defined earlier within this chapter. This could also be added to other discriminatory tags if they are already added to the learning object as learning objects can support multiple tags associated with numerous learning object discriminations.

Step 5: Implementation of the discriminatory tagging

Implementation of this discriminatory tagging may potentially need to follow the course/topic structure of the system (due to possible pre-defined hierarchy) but this will depend on the e-learning platform or system. The xml schema design and tag set would then need to be incorporated into the chosen platform or system and the tag choices should be made available for the instructor at the time of file upload. These tags should then be related to the specific learning or assessment object. Searching based on the tags according to the tag set choices would also need to be implemented and for this the code may be system implementation specific.

Some learning environments (e.g. Moodle) support tagging, however others do not and in that case the implementation of the authoring and search functionality would be more complex and technical assistance would be required. More information about the implementation stage is discussed within chapter 5 in section 5.4.

4.8 Summary

This chapter describes the work to satisfy the research aim of "to develop a unique approach that supports the personalisation of learning materials and the use of learning styles".

It also completes the first part of the objective of "to create and evaluate a model to offer personalised learning based on a learner's learning style" as set out in the introduction to this thesis. This objective was completed by using the tagging concept and adheres to standards corresponding to the requirements highlighted within the research findings of Chapter 3.

The initial hypothesis has changed based on the outcome of the background research as the mechanism has been designed to incorporate the use of a discriminatory tagging methodology that allows the expansion of the use of learning objects in the context similar to the adaptive hypermedia model. The metadata tags allow the instructor to control how the learning object is used and represented.

As discussed earlier, tagging the learning objects as described within the methodology will allow the content of a learning object to be consistently represented within e-learning platforms or other e-learning systems. The learning objects can therefore be tagged so that they are visible to learners at a level of study, with a particular background level and discrimination requirements.

The end of this chapter shows a worked example of the stages of the methodology. The background research undertaken within this project identified the benefits of personalised and adaptive learning, and this methodology provides a mechanism for achieving them. The methodology steps are to first define the key characteristics of the discrimination type for the tagging, next to create the semantic rules, xml, xsd and the tag set before undertaking the implementation within the chosen learning environment.

This worked example demonstrates that this methodology can be used for multiple discrimination models and learning objects can be tagged within multiple tags for different discriminations and not just for learning styles. Therefore at this stage of the project the hypothesis was revised to, "a discriminatory tagging methodology can be developed to provide personalised learning materials to an individual learner".

This project started out by applying learning styles to create personalisation, however, the methodology that has been created is much more powerful than the simple application of learning styles. It is powerful as there are no limits to the discriminatory types and tags and so therefore the learning objects can be tagged for multiple discriminatory models. Currently metadata models (e.g. LOM IEEE) do not offer such flexibility, as the discrimination is very limited within these models, and focuses mainly on discriminating by the level of difficulty of the learning object.

This methodology allows for users to create and share schemas. One issue with this is that people may use different tags to define the same things; therefore a technique such as global schematic mapping could be used here in order to create ontology of terms to handle the complexity. Unlike the metadata models, the xsd created within the methodology therefore allows flexibility, capability of sharing, reusability and multiple tag systems being available for the learning object.

After the initial tagging and metadata designs the next phase of this project was to implement a prototype of the discriminatory tagging demonstrating the VARK discrimination. Initially, this led to an evaluation of a number of implementation choices. These choices and the actual prototype implementation are discussed within detail in the next chapter.

5 Implementation: Moodle incorporating tagging for personalisation and reuse

5.1 Introduction

The implementation step for the discriminatory tagging methodology described in the previous chapter is discussed within this chapter. Initially this chapter discusses the implementation choices available for this prototype and describes how the prototype implementation was developed as an extension of Moodle. This chapter describes the reason why Moodle was chosen for the development and together with discussing the alternative choices available. Additionally, it describes a number of advantages found for using Moodle for this purpose.

A description is also given discussing how Moodle was enhanced to incorporate the learning object authoring and discriminatory tagging. Moodle has pre-defined functionality that is used to incorporate the functionality of the tagging and also has plug-ins and modules available which incorporate the tagging. Therefore both of these pre-defined and plug-ins are described and evaluated within this chapter.

The authoring and search functionalities developed within Moodle are described in detail in this chapter. The implementation is discussed, and additionally, some worked examples of the developed functionality are also described in detail in this chapter.

The final section of this chapter discusses the platform independency of the discriminatory tagging methodology and describes common steps that would need to take place in order to implement the methodology within a learning environment. This section also describes how this methodology allows for multiple users and some issues surrounding this.

5.2 Moodle as the development tool

In order to create a prototype system to demonstrate the tagging, various implementation methods were investigated. Initially the suitability of semantic web technologies was evaluated. Next, it was investigated whether it would be suitable to build an e-learning platform from scratch or whether it would be more advantageous to develop and enhance an existing platform to incorporate the tagging. These experimental investigations are now discussed in further detail.

The initial tag design was designed within a semantic web environment, specifically designed in RDF and OWL and designed using the Protégé software. However, after much investigation it was found that developing the implementation within this environment would not be suitable due to the limitations of the technology available. It was also the fact that the functionality available would not be flexible enough to incorporate the required e-learning platform functionality.

A basic prototype of the system was then developed using C# and asp.net. Although this was a useful exercise, the result of this prototype development highlighted concerns about the lack of functionality for both the instructor and the learner. Instructors and learners are so used to a set of functionality within e-learning platforms (for example course and learner management tools) and it was thought that attempting to replicate this type of functionality would not be feasible for this project.

The outcome of these initial investigations was, that it was felt that enhancing the functionality of a current e-learning platform would be a good tool for implementing the tagging. This was due to the fact that the research within earlier chapters has shown that e-learning platforms are a popular choice for e-learning and that they offer good tools for both the instructor and the learner. It was felt that as these tools were already available, it would be more appropriate to develop and extend an existing e-learning platform rather than creating one from scratch.

Additionally, the research discussed in previous chapters also showed that current popular e-learning platforms have very limited personalisation and adaptability for the learner and therefore it was decided that a current e-learning platform would be developed and extended to incorporate the tagging. It was thought that it would be beneficial for the learner to have a more personalised learning experience within a familiar learning environment as the research into personalised learning shows that this is beneficial for the learner.

With this in mind, available e-learning platforms were evaluated for their suitability for extension and development and it was decided that Moodle would be the most suitable for this purpose.

The main reasons for choosing Moodle were:

- Research studies such as Kurilovas (2005) and Graf (2005) discuss the benefits of using and enhancing Moodle.
- Moodle is open source and is therefore easily available.
- Moodle is a commonly used e-learning platform and the University of Greenwich is currently moving over to Moodle. Therefore this is an obvious advantage to this project.
- Moodle has an active developer online community with many plug-ins available. This environment has many forums and blogs available for the community and these are widely used by the community.
- Moodle also has good pre-defined functions and modules that can be extended. This is unlike other platforms such as Blackboard, which are not easily extendable.
- Moodle has additional plug-ins available that can be extended.

The next section of this chapter discusses how Moodle was enhanced to incorporate the tagging design that was described within the previous chapter.

5.3 Enhanced Moodle functionality

Initial investigations into Moodle and tagging found that current versions of Moodle have searchable tags available for the learner's interests but no other tagging exists for the learning resources, topics, courses and categories.

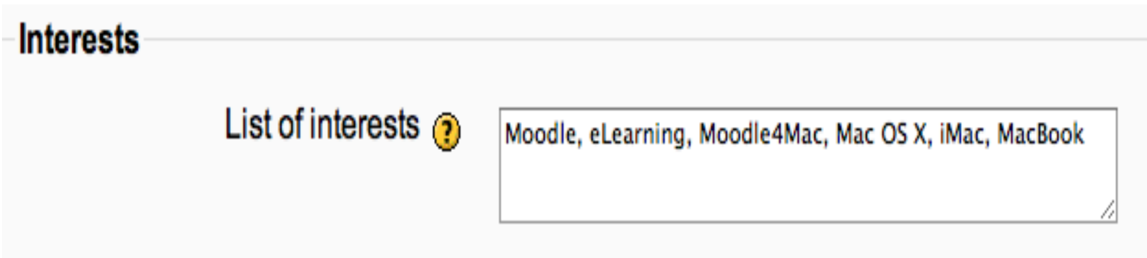


Figure 20: User interest tags in Moodle

A Moodle user can update their interest tags for their profile as shown in Figure 20. These tags are editable by the user and can then be viewed by users in the Moodle Start page within a block showing the tags as shown in Figure 21. By clicking on the eLearning tag, for example, it will show details of all users who have put e-learning as an interest.

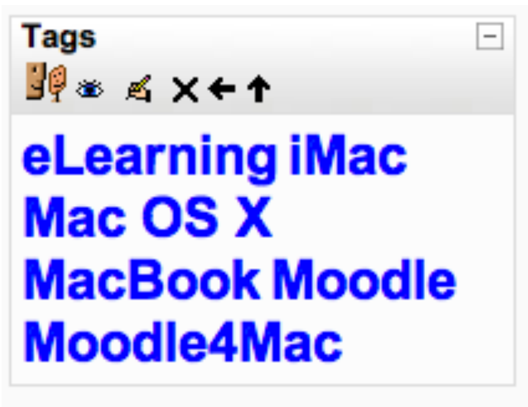


Figure 21: Block showing Moodle tags for learner's interests

As tagging is not available for courses and objects initially an investigation took place into creating a Moodle plug-in to incorporate the tagging and also to investigate current available plug-ins.

Some basic initial prototype Moodle development was undertaken and a basic prototype plug-in within Moodle was initially developed. The basic prototype was contained in an installable Moodle block and this exercise provided an understanding of the modules and blocks available within Moodle.

At this initial prototype development stage an investigation into Moodle modules and plug-ins was also undertaken to see whether any of these would be suitable to use for this development.

It was found that many open source plug-ins and modules are available for Moodle and so the outcome of this investigation and the initial prototype development resulted in a decision that the best way forward would be to develop the personalisation and tag design by using the existing modules and enhancing the existing functionalities available offered within the current plug-ins.

One plug-in in particular was found to be particularly interesting and this was product of a JISC funded project called MrCute Jr. (2009). MrCute Jr. contains the functionality that allows the instructor to add learning resources that can then be shared within the system rather than being attached to a course as in the default Moodle module. It also contains the basic functionality to enable a search for these learning resources based on a basic search criteria.

It was felt therefore that this plug-in would be useful if it could be adapted as for the proposed authoring tool the learning and assessment objects should be searchable by keyword by all learners.

According to the Moodle documentation MrCute Jr. is "a Moodle resource type plug-in that enables a way to share URL/File resources across Moodle courses and make them easy to find". It was felt therefore that the best way forward would be to extend this plug-in rather than trying to develop a completely new plug-in to incorporate the tagging.

Therefore, the MrCute Jr. plug-in was installed and tested in Moodle. It was found that this plug-in had the functionality of adding a new shareable resource or URL with title, description and keywords metadata. This plug-in also contains a search functionality, specifically searching for learning objects based on the title, description and keywords metadata.

This plug-in was adapted and extended using the PHP programming language to incorporate the tagging described in the previous chapter. The plug-in extension developed incorporates the VARK discrimination model by incorporating the schema design and tag set for a learning resource. The implementation extension also contains tags for the instructor to select, which are held within drop down lists at the time of learning object upload. The instructor makes a selection of objects and these are saved as tags corresponding to the learning objects. Additionally, the search functionality has an extended learning resource search function

The implementation of this prototype is therefore described within the following sections, highlighting the plug-in extensions.

5.3.1 Authoring and tagging the learning content for VARK discrimination

Moodle was chosen as the implementation tool for the VARK discrimination example due to the existence of support for the modules, plug-ins and an extensive developer community. Moodle has a topic course structure available and, at the time of implementation, this seemed to be the most appropriate way to add the subject and topic hierarchy described within chapter 4 to the system. The rest of the tagging mechanism was directly coded by the instructor, and added as an extension to the original Moodle implementation. The top hierarchy subject tag is the Moodle course name and the topic group tag is the topic within the Moodle course. The MrCute Jr. plug-in provides a repository of learning resources that are attached to a particular course in Moodle, and searchable by keyword, contained within the tag, for all learners, not just learners on the course. This repository is used to store the learning objects and corresponding tags. This plug-in was extended further in order to incorporate the schema design and tag set and this extension is described in detail within this chapter.

Using the Moodle course for the subject and topic groups, the initial implementation extension of the modules and plug-ins was to create the form for the input of the appropriate tags as per the schema and tag set (see Table 6) at the time of file upload. The tag selections available from the tag set were put into drop-down lists containing a choice of tags available for the instructor to select. Once selected these tags were saved as related to the learning object within the learning object repository so that they are able to be searchable by learners.

Tag	Possible values
Type	Learning Object, Assessment Object
File_Type	Audio File, PowerPoint(with audio), PowerPoint(without audio), Podcast, Multimedia, text, Video
Description	Free text
Resource_Type	Lecture, Exercise, Simulation, Narrative text, Experiment, Exam, Problem assessment, Self assessment
Level	1st year undergraduate, 2nd year undergraduate, 3rd year undergraduate, masters
Keyword	Free text

Table 6: Tag set for VARK discrimination

The VARK discrimination implementation within Moodle is described in more detail within the next section.

5.3.1.1 Authoring the subject and topic hierarchy

The hierarchy of subjects, topics and learning object groups (LOG's) are defined within Moodle as standard course categories, course sub-categories and topics. The system was implemented this way as it allows the instructor to be able to define the categories and topics according to the specific subject domain.

The existing default course structures available within this version of Moodle are LAMS, SCORM, Social, Weekly or Topic. For this implementation, the Moodle default course structure is set to a Topic format.

This default topic format will therefore mean that all new courses created will have a topic format. Setting up the course this way will ensure that the instructor can add a new topic for a course as required.

Figure 22 shows an example of some course categories and sub-categories within Moodle. This figure displays "programming" as a course category and "asp.net programming", "java programming" and "PHP" as course sub-categories. The instructor could add more course categories and sub-categories as required.

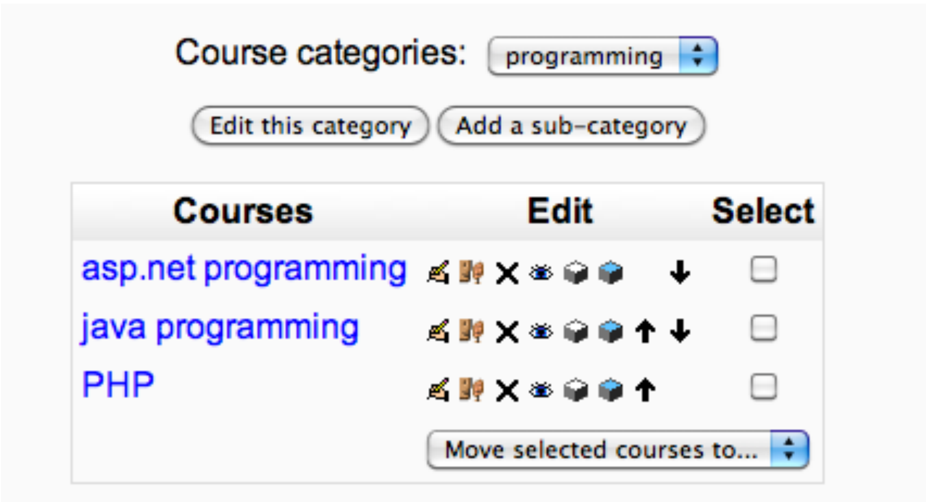


Figure 22: Course categories and sub-categories

To extend this further, an example of subject, topic groups and learning object groups has been defined within Moodle as follows:

Programming:

- Moodle course (category)

Asp.net:

- Moodle course (sub-category)

Basic web:

- Moodle topic (course structure topic)

CSS:

- Assessment and learning objects

HTML:

- Assessment and learning objects

Creating the subject and topic domain in this way also allows for the learning and assessment objects to be added at different category levels. For example, the instructor may have an assessment for the "asp.net" course level, and also an assessment for the "basic web" topic level and so this could be added within this authoring tool.

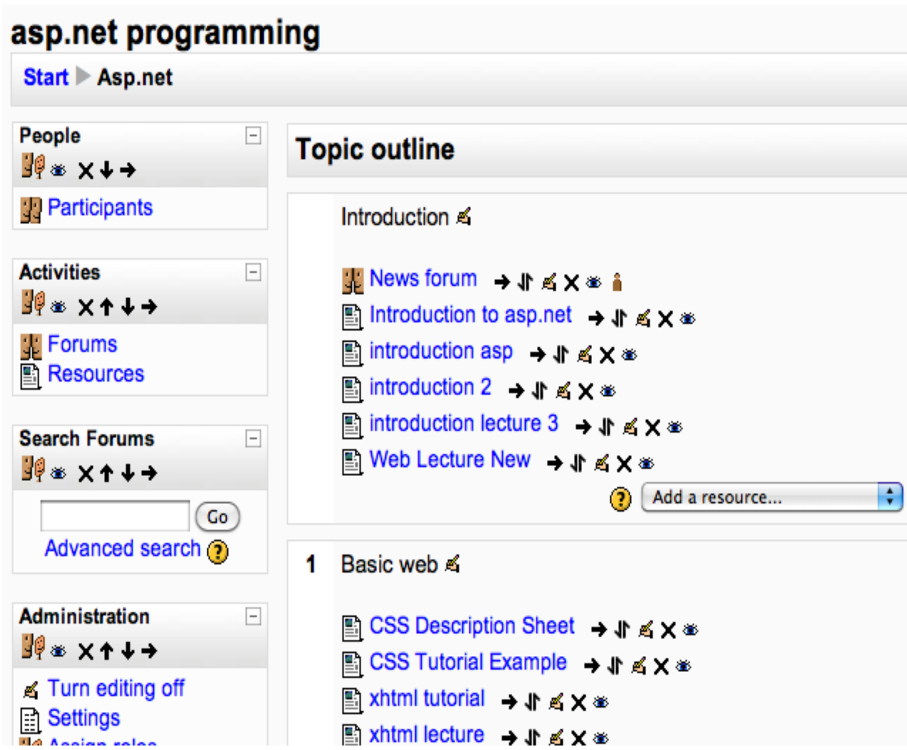


Figure 23: Instructor view for sub-category course

Shown in Figure 23 is an example of an instructor view for the "asp.net programming" course and the course as topic outline in Moodle. This figure also shows the "basic web" topic within Moodle. This window is editable and is where the instructor will select the topic and then link to the page that will upload the learning and assessment objects and tags. This is described in detail within the next section.

5.3.1.2 Authoring the learning and assessment objects tags

The tagging authoring tool has been developed to allow the instructor to input the tags for the learning and assessment objects when uploading and creating the new object. These objects then become searchable learning objects that learners can search and view based on their own specific requirements.

The searchable resource is a new resource type within Moodle that is available from the resource menu within the edit course window. This new resource type is an extension to the standard file or URL resource type within Moodle.

For this implementation, a new searchable file resource is added to Moodle and the difference between this new resource and the standard Moodle file resource is that this resource is searchable, whereas the standard Moodle file resource is just attached to the specific course that it is uploaded to. The MrCute Jr. plug-in was therefore extended to incorporate part of the tagging. The plug-in contains the functionality of adding a searchable learning object and for keyword and description tags to be added. The other tags were added on top to this to enhance the functionality for the implementation.

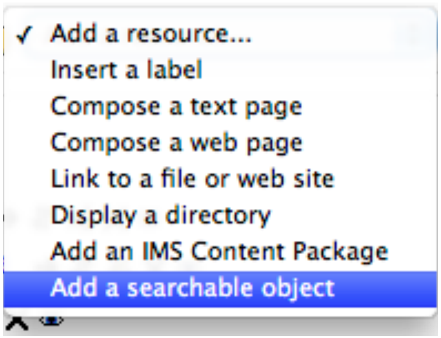


Figure 24: Resource selection of the new searchable resource type

The "add a resource" list showing the new searchable object is shown in Figure 24. This figure shows the default resource selections including the standard link to a file or web site resource within the list. The new "add a searchable object" resource is also in the list and is highlighted within Figure 24.

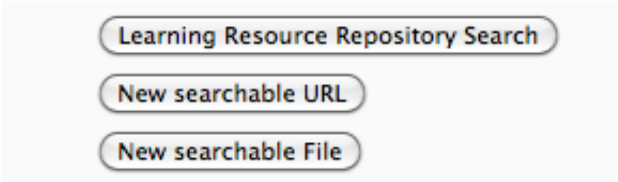


Figure 25: Shareable object choice

Selecting "add a searchable object" from the resource list will provide the instructor with an option to search the learning resource repository for the new object, add a new searchable URL or add a new searchable file (see Figure 25). Once the instructor makes the resource selection, the window containing the form to add the new object and tags are provided to the instructor.

Figure 26 shows the "add new searchable file" window where the instructor can upload the new object and add the corresponding tags. This window shows the instructor the current subject and topic. For this example the subject is "asp.net" and the topic is "basic web".

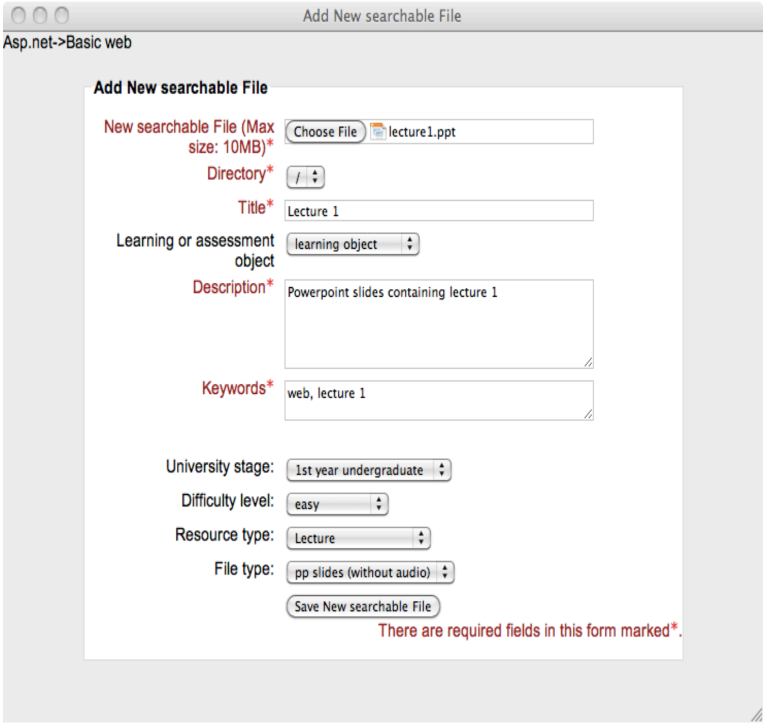


Figure 26: Add new searchable file window

Initially, the instructor can choose the file to upload and then add the metadata tags for the learner profile and the learning style representation. These tags were added as an extension to the new searchable resource. This resource is searchable and these tags can all be searched by the learners and also by other instructors.

When a new learning resource has been uploaded, an instructor can add a title and then add a tag to define whether the object is a learning object or an assessment object.

The instructor can then add a description and keyword tags that can be used to provide extra information to the learner about the object. However, description and keyword tags are not used as part of the search criteria at present due to possible issues with the semantic meaning and consistency of these words. Once the issues with semantic meaning and consistency are resolved, this could be an additional enhancement to the search functionality. The description and keywords, however, are useful as they are displayed to the learner with the object in the search results to give more information to the learner about the object.

The learning stage and level can be added as a tag to the learning and assessment objects by offering the instructor the selection within drop down lists. One list contains the university stage (1st year undergraduate, 2nd year undergraduate etc.) and one list contains the LOM metadata difficulty (very easy, easy etc.) as described within the previous design chapter.

For this system, the instructor will have to assess the level for the particular learning material and add the tag. This will therefore be initially down to the judgement of the instructor who will assess the appropriate level.

The resource type tag can also be added to the system by the instructor, and as described in the design chapter, the resource type tag is modelled on the LOM resource type and could be: Lecture, Exercise, Simulation, Questionnaire, Diagram, Figure, Graph, Index, Slide, Table, Narrative Text, Exam, Experiment or Problem Assessment. The instructor can make the selection and the selected tag will be stored for the learning or assessment object. The instructor also has the option to select the file type for the object. For example, the file type may be PowerPoint slides (with or without audio), Podcast, Multimedia, Text or Audio. Different file types could be added to the system as needed.

All of the tags described here are saved for the corresponding learning and assessment objects corresponding to the xml schema. Once the tags are saved and added for the object they then become searchable tags. The tags can be searched by the learner within the block containing the search functionality as described within the next section.

5.3.1.3 Learning object authoring example

An example of an instructor authoring a learning object is as follows:

An instructor wants to upload the following:

- Type: learning object
- Subject/topic: asp.net programming / introduction
- Title: Basic web lecture
- Level: 1st year undergraduate – easy
- Resource type: Lecture
- File type: PowerPoint slides (without audio)

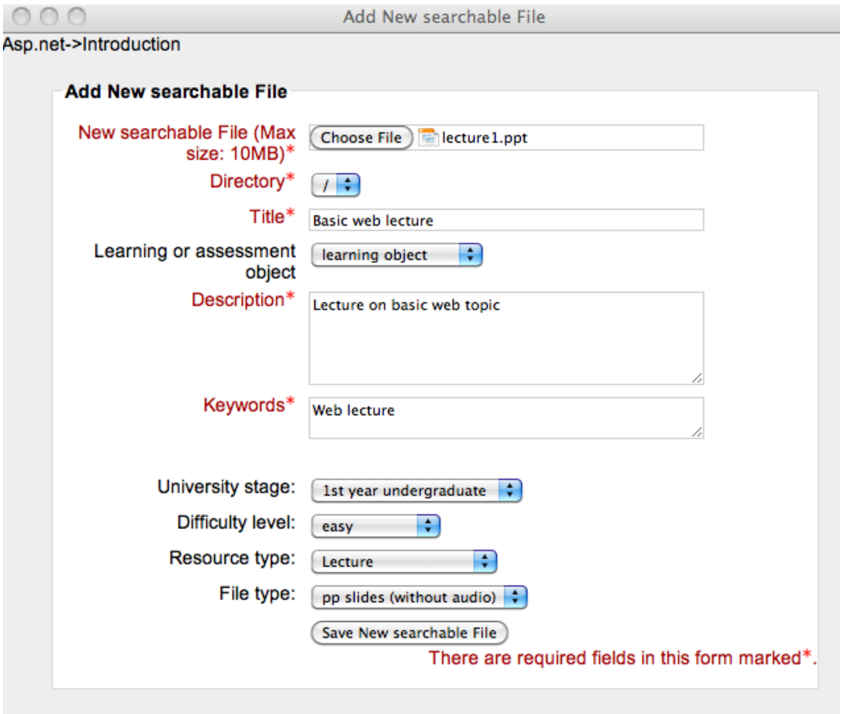


Figure 27: The completed form for the learning object example

The steps that the instructor will take are as follows:

1. The instructor will first navigate to the asp.net programming course and the basic web topic and make the topic page editable.

2. The instructor will select the resource type as the new searchable object.

3. The instructor will upload the file and complete the form with the tags as shown in Figure 27.

4. The instructor will then save the object and corresponding tags. The object will then become searchable.

5.3.2 Searching the tagged learning resources

The search facility (called the Learning Resource Repository) has been implemented as an installable block available from the main start page of Moodle. Figure 28 shows the search block as seen from the Moodle start page.

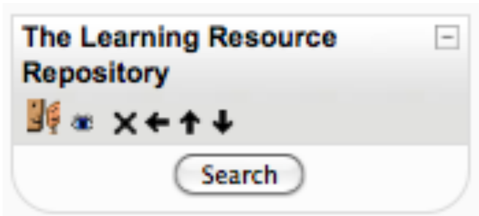


Figure 28: The search block available from the Moodle start page

The learner search functionality was implemented as an extension of the MrCute Jr. block. This block allows for searching by keyword tags. The extended search functionality offers more search options including searching based on the tags defined by the instructor.

This block was therefore extended for this implementation to allow searching of the repository for subject, topic, level and also the VARK discrimination tags. A search form was created to support selection of the relevant VARK tag(s), the subject, topic and university and also a hyperlink for the VARK questionnaire. The tag selections available from the tag set are put into drop down lists for the user to select.

Both learners and instructors can use this search function. The instructor can search for the learning and assessment objects whilst uploading a new learning and assessment object as described in the previous chapter. This will allow the instructor to reuse objects and also find objects that are suitable for a particular type of learner. The learner can search the learning and assessment objects from the main Moodle Start page.

Figure 29 shows the main search page. This search page offers a hyperlink to the web page of the VARK learning style questionnaire. The learner can complete the questionnaire and once complete will be provided with their learning style type. The learner can then add their learning style type to the learning object search form and their learning style will be saved in their profile. If the learner would like to complete the questionnaire again at any time they are able to do so and a new updated learning style type will be saved for the learner.

The learner can then complete the search criteria by adding their own search criteria, they can search objects suitable for their learning style or if they prefer they can search all of the learning objects for the subject and selected topic. It was felt that this would be beneficial to learners, as they may not just want to view objects suitable for their learning style. This also directly address the criticisms of learning styles described in a previous chapter, as it does not restrict the learner to one learning style type.

Figure 29 shows a completed example of the learning object search screen that the learner or instructor will be able to view. Although an instructor can also view this, this section will focus mainly on how a learner would use this search functionality.

Once the learner has added their search requirements, they will be provided with objects based on their requirements. The search results show details of the searchable tags for the objects. The learner can make object selections and then save the selected objects.

The learner is able to search for the learning objects based on their learning style type (VARK combination), knowledge level (undergraduate first year, second year, third year or Masters) and course/topic requirements (specific to the domain).

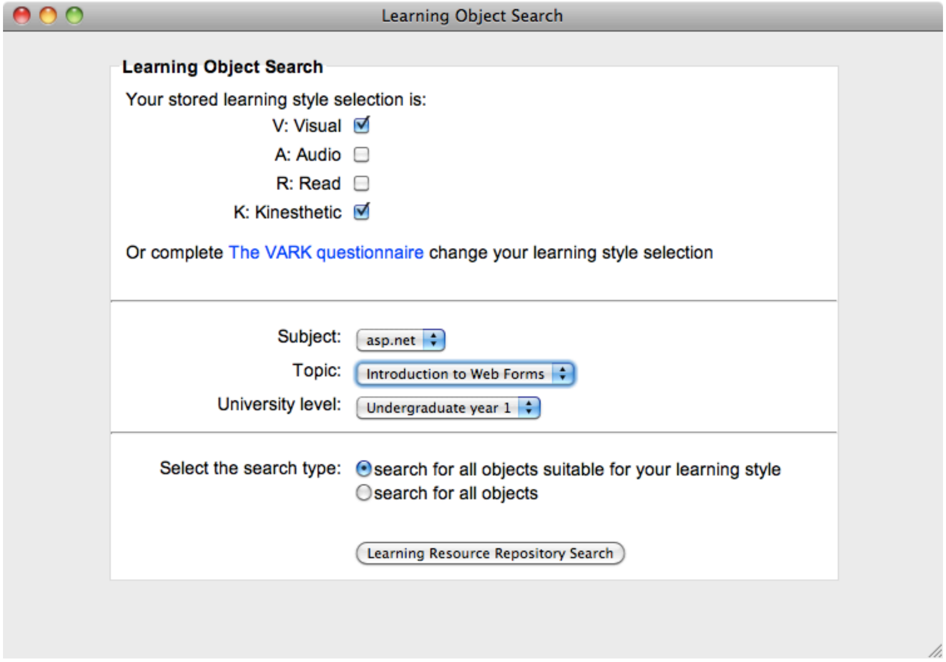


Figure 29: Learning object search screen

An example learner search and the object recommendations are as follows:

An example learner search input:

- **Course required:** asp.net
- **Topic required:** introduction to web forms
- **Level:** undergraduate year 1, easy
- **Learning style:** VK

The system searches for learning objects tagged with "asp.net", "introduction to web forms", "undergraduate year 1", "visual' and "kinesthetic".

Objects that are returned, and therefore recommended, have the following tags:

- **Subject** (asp.net)
- **Topic** (introduction to web forms)
- **Level** (undergraduate year 1, easy)
- **File type** (video or vodcast or Powerpoint or multimedia)
- **Resource** (diagram or figure or graph or simulation or experiment or problem assessment)

An algorithm for this tag search is as follows:

```
If subject == "asp.net" AND topic == "introduction to web forms"
THEN
        If level=="year 1" THEN
              IF File_type == "video" OR File_type == "vodcast"
              OR File_type == "powerpoint" OR File_type ==
              "multimedia" THEN
                           Select file
              End If
        End If
End If
```

The system will recommend learning and assessment objects to the learner based on their specific requirements. Additionally, the learner will also have the opportunity to browse all objects within the required course and topic as they may not want to be restricted to objects only based on their learning style category. This is because some learners might not wish to be restricted to viewing only objects suitable for their learning style.

Icon	Add learning object: shared file or website	Type	Resource type	Modified	Select object
	Introduction to xhtml - PowerPoint slides containing an introduction to xhtml (Keywords: web, xhtml)	File	PP Slides (without audio)	2011/05/23 (May)	☑
	asp.net tutorial - tutorial (Keywords: asp.net tutorial)	File	Text	2011/05/01 (May)	☐
	xhtml lecture - xhtml lecture notes (Keywords: xhtml)	File	PP Slides (without audio)	2011/03/28 (Mar)	☑

Figure 30: Example learning object search results

The learner is then able to select, view and download all of the required recommended objects. Figure 30 shows example search results showing the file type icon, a hyperlink to download the file, the file description and keywords for the object and the resource type.

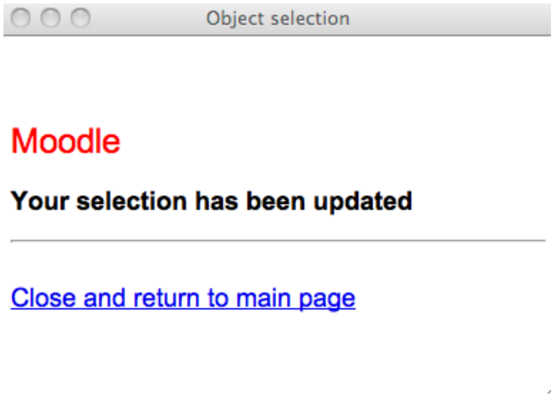


Figure 31: Moodle saving confirmation window

The learner can select the objects as required and then these objects can be saved and added to their personalised learning package. The learner could have different packages based on different topics required. They will then be able to view objects they have selected within this package. Figure 31 shows the Moodle saving confirmation window.

As discussed in the previous chapter, the personalised learning package will enable the learner to manage their own learning and learning space. Allowing the learner to select their own learning objects is supportive of a heutagogic learning model, in which the learner makes selections from a range of resources according to criteria that they define to support their own learning.

5.3.2.1 VR learner type example search

This is an example search for an undergraduate year 1 learner with the Visual and Read/Write (VR) learner type.

This particular learner would like to search for learning and assessment objects for:

- Asp.net course
- Introduction to web forms topic

The learner would like to search for all objects within this topic that are suitable for their particular learning style type.

To undertake a learning and assessment object search, the learner completes the learning object search form shown in Figure 32. As shown in Figure 32, the learner would check the V:Visual and R:Read boxes, select asp.net, introduction to web forms, undergraduate year 1 and select to search for all objects suitable for the learning style.

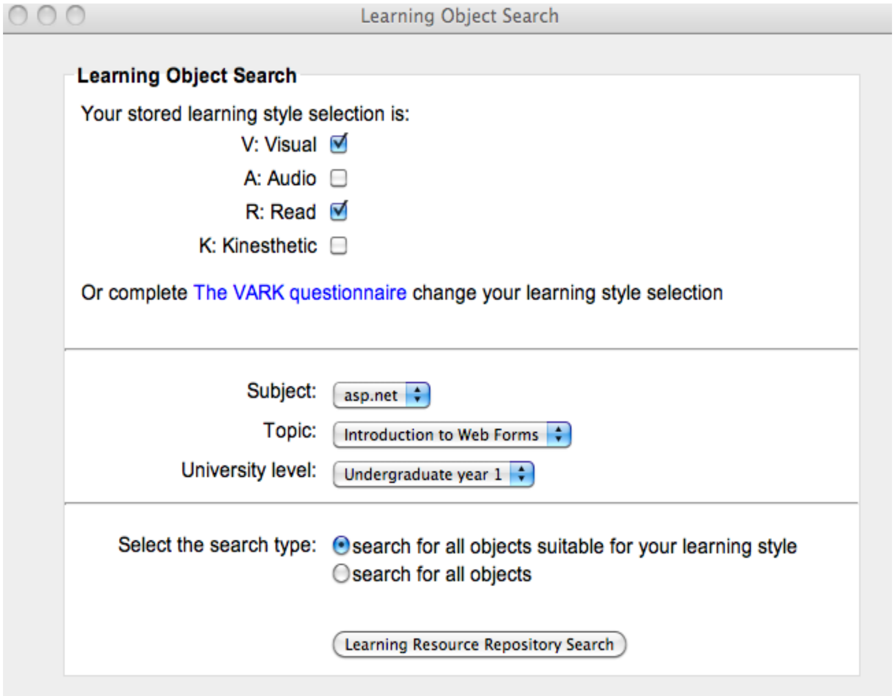


Figure 32: Learner with VR learning

The system searches for learning objects tagged with “asp.net”, “introduction to web forms”, “undergraduate year 1”, “visual’ and “read”.

The search results are then provided to the learner. An example of these learning and assessment object results are shown below in Figure 33.

asp.net page layout video - Video showing how to layout a page in asp.net (Keywords: asp.net web forms layout)	URL	Vodcast
Basic web forms video - Basic web forms video (Keywords: asp.net web forms)	URL	Vodcast
asp.net validation exercise - asp.net validation (Keywords: asp.net validation)	File	Text
asp.net validation exercise - asp.net validation (Keywords: asp.net validation)	File	Text
web forms exericse - tutorial exercise web forms (Keywords: asp.net web forms)	File	Text
web forms exericse - tutorial exercise web forms (Keywords: asp.net web forms)	File	Text
creating the asp.net interface - asp.net interface creation (Keywords: asp.net interface forms)	File	PP Slides (without audio)

Figure 33: Recommended objects for learner with VR learning style search

The search results provided contain Vodcasts, Text and PowerPoint (without audio), which are object types suitable for learners with the VR learning style type. Vodcasts, Text and PowerPoint are all suitable for learners with the Visual learning style type and Text files are suitable for learners with the Read learning style type. The learner can then download, view and save the required learning and assessment objects.

5.3.2.2 AK learner type example search

This is an example search for an undergraduate year 2 learner with the Aural and Kinesthetic (AK) learner type. This particular learner would like to search for learning and assessment objects for:

- Asp.net course
- Introduction to web forms topic

The learner would like to search for all objects within this topic that are suitable for their particular learning style type.

To undertake a learning and assessment object search, the learner completes the learning object search form as shown in figure 34.

The learner would check the A: Audio and K: Kinesthetic boxes, select Asp.net, Introduction to web forms and Undergraduate year 2 and select to search for all objects suitable for the learning style.

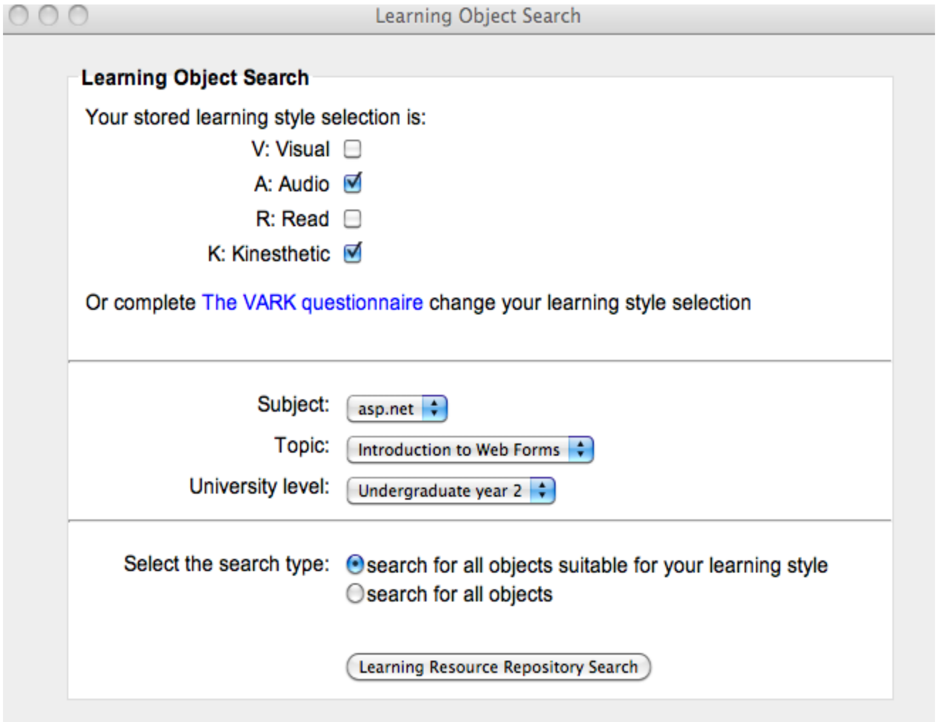


Figure 34: Learner with AK learning style search

The search results are then provided to the learner as shown in Figure 33. The search results provided contain Multimedia and PowerPoint with audio, which are object types suitable for learners with the AK learning style type. Multimedia files are all suitable for learners with the kinesthetic learning style type and PowerPoint (with audio) files are suitable for learners with the Audio learning style type. The learner can then download, view and save the required learning and assessment objects.

Introduction mm file - Introduction to web forms (Keywords: web forms)	File	Multimedia	2011/07/11 (Jul)
Web forms other issues - Web forms other issues with audio (Keywords: Web forms audio)	File	PP Slides (with audio)	2011/06/23 (Jun)
Web forms file with audio - Web forms file with audio (Keywords: web forms audio)	File	PP Slides (with audio)	2011/06/23 (Jun)
Web form mm file - asp.net web forms (Keywords: web forms)	File	Multimedia	2011/06/23 (Jun)
Web form mm file - asp.net web forms (Keywords: web forms)	File	Multimedia	2011/06/23 (Jun)

Figure 35: Recommended objects for learner with AK learning style search

5.4 Platform independency and multiple users

Described within this chapter the Moodle implementation of the subject/topic hierarchy design uses the fixed course structure within Moodle. This may not be the case for other implementations, as it will depend on the structure of the hierarchy. Within the initial prototype implementation undertaken in C# the subject/topic hierarchy was created from scratch and added to the database to reflect the subject/topic hierarchy defined within the design described in Chapter 4. Figure 36 shows the prototype C# where an instructor can add learning objects by uploading a file and inputting the tags, and also select the subject and topics.

When comparing C# prototype implementation screen in Figure 36 to the Moodle implementation screen Figure 27 it can be seen that for the two implementations the same file upload and tag input is required and so therefore these two screens look very similar. This demonstrates that the same, or very similar, user interfaces can be developed, irrespective of platform. The major difference between the implementations will be in the creation of the subject/topic hierarchy to support the tagging system.

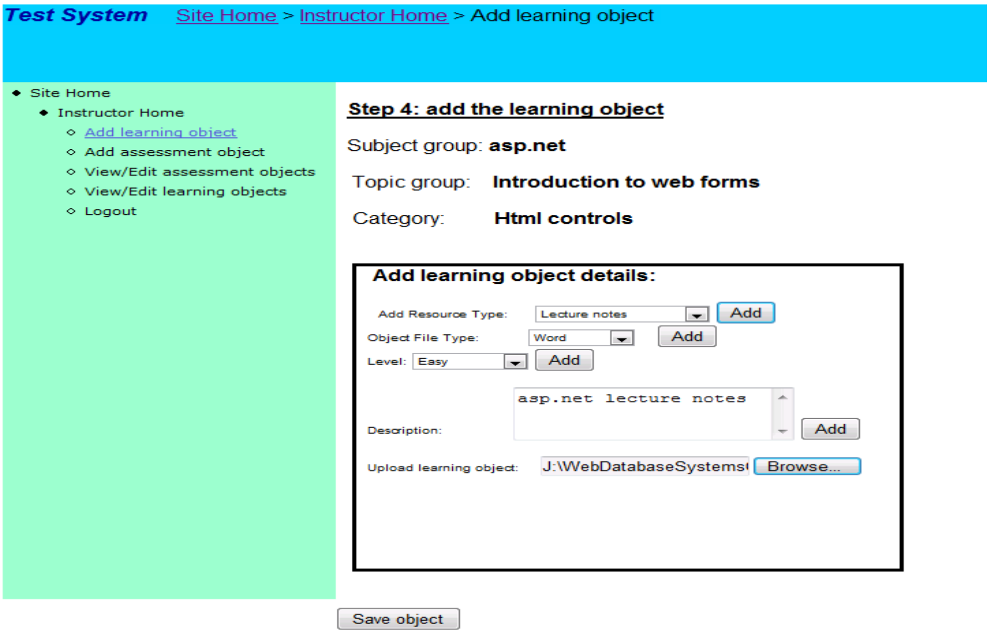


Figure 36: C# prototype implementation learning object upload screen

Moodle supports tagging, therefore the in-built tagging system was utilised to associate VARK discriminatory tags with the learning objects. However, within the C# prototype implementation, the tagging needed to be implemented directly by the instructor. If other learning environments do not support tagging then the learning object authoring and search would need to be built on to the system, using a relevant API and developing code for the tagging and searching. Therefore, the actual code for the implementation will vary according to the learning environment.

Although the actual code for the implementation will differ according to the learning environment, implementing the discriminatory tagging design in both C# and Moodle highlighted some common steps that need to be taken in order to implement the tagging and searching. The common steps are as follows:

- Add the xsd schema and tag set design to the system. This should include the standard IEEE LOM description, level (extended as described in chapter 4), keyword tags and also tags corresponding to the specific discrimination requirements. Figure 37 shows the xsd in the C# prototype implementation example.

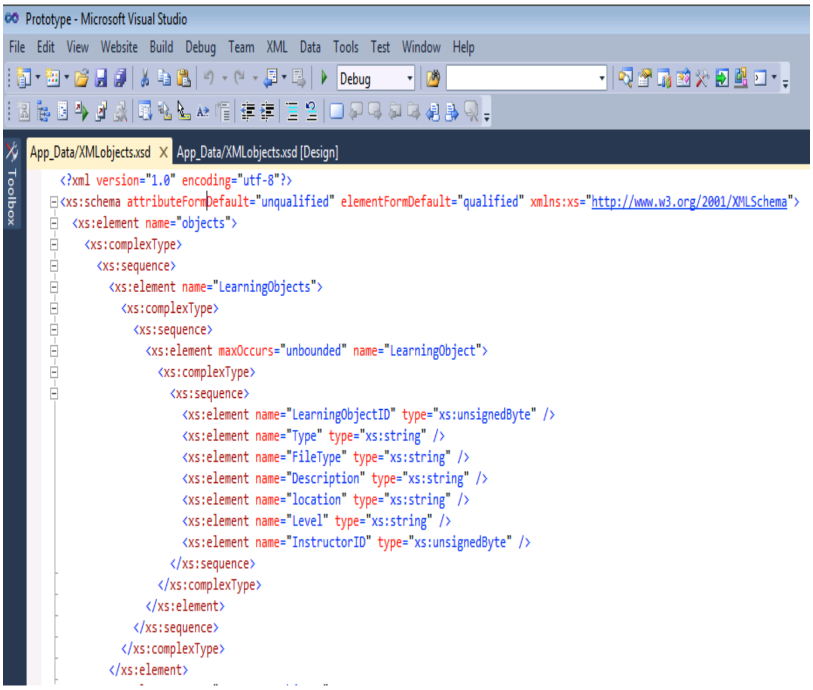


Figure 37: The xsd within the C# prototype

- Create the user input form for the learning object file upload and the input of the tags using xsl or css for style and formatting. This input form should contain the tags available from the tag set and should be similar to the Moodle screen shown in Figure 27 and the C# screen shown in Figure 36.
- Save the tags related to the learning objects so that they will be searchable.

  Code will vary according to the implementation, however example code of how this is done in the C# implementation follows:

```
XDocument xmlDoc = XDocument.Load(mapLoc);

xmlDoc.Descendants("LearningObjects").FirstOrDefault().Add

(new XElement("LearningObject",
new XElement("LearningObjectID", GetTableID),
new XElement("Type", ddLOFileType.SelectedItem.Text),
new XElement("FileType", ddLOobjectType.SelectedItem.Text),
new XElement("Description", txtLODescription.Text),
new XElement("location", SaveLOURL),
new XElement("Level", ddLevel.SelectedItem.Text),
new XElement("InstructorID", InstructorID)));

xmlDoc.Save(Server.MapPath("~/App_Data/XMLobjects.xml"));
```

- Create a search facility for objects corresponding to discrimination type. For part of the accessibility example (as described in Chapter 4 Section 4.7) this would be that, for a person with a visual disability, the system would be able to search for all learning objects tagged with “pp with audio”, “podcast”, “multimedia with description”, vodcast (with description). The accessibility type and file types would be mapped onto variables, the content of which could be searched. For example, the algorithm for this would be:

```
If accessiblityType == “visual” THEN
 IF File_type == “pp with audio” OR File_type == “podcast” OR
 File_type == “multimedia(with description)” OR File_type ==
 “vodcast(with description)” THEN
        Select file
 End If
End If
```

The discrimination tagging implementation is scalable, in that multiple users will be able to use the tagging, as the xsd schema is portable and can be incorporated into e-learning environments or other appropriate systems. The instructor can create a new schema or reuse an existing one supporting flexibility of use, author autonomy, and sharing of resources. The tag set then provides the facility for the instructor to tag the learning objects, so that they can be made searchable. The xsd is very powerful as it can be provided to a community of instructors to enable standardised tagging, in a similar fashion to the existing provision of metadata models. However, it also allows much greater flexibility and freedom to instructors who don’t wish to be bound to a standard monolithic model, and wish to develop and extend their tag sets autonomously.

One possible issue with multiple users wishing to set up new xsds and discriminatory tags is the introduction of heterogeneity between the schemas. Some instructors may use different tags to describe the same things, known as semantic heterogeneity. As mentioned previously, this concern was by Li and Lu (2008) who found that one of the challenges in tagging systems are the inconsistency and ambiguity of tags. One technique that could be used here is global schematic mapping. The database community uses this technique to create an ontology of terms to support interoperability, which addresses this issue.

This sharing of schema definitions therefore supports instructor autonomy and using this technique is also much more flexible than using standardised metadata (e.g. LOM IEEE or Dublin Core). The xsd, however, can also be incorporated into a system containing a standard metadata model (e.g. Jorum) to provide a greater level of flexibility within that system.

Additionally, this methodology offers the capability to have multiple tag sets in use simultaneously, providing support for numerous different types of discrimination, something that the standard metadata model cannot offer at present.

This methodology therefore offers a novel approach, as this flexible mechanism of tagging learning objects for discrimination is currently not available within any learning environment.

5.5 Summary

Together with chapter 4, this chapter describes the work to satisfy the research aim of "to develop a unique approach that supports the personalisation of learning materials and the use of learning styles". This unique approach has been achieved by using tagging to provide authoring control of searchable learning objects, enabling learners to create personal learning catalogues.

This chapter also described the implementation of the methodology which satisfies the evaluation part of the objective "to create and evaluate a model to offer personalised learning based on a learner's learning style" as set out in the introduction to this thesis.

Moodle has been utilised as the tool to develop the tagging prototype, due to the fact that it is an e-learning platform that supports tagging with pre-defined modules and functions, and this has obvious advantages for the system development.

Referring back to the research hypothesis of "a mechanism can be developed to personalise learning materials to an individual learner according to their learning style", this chapter describes how this mechanism has been implemented within Moodle. However, this discrimination tagging is flexible and can be implemented within any e-learning system or any appropriate platform. Although the actual code for the implementation may differ, Section 5.4 describes the common steps that need to be taken when implementing the discrimination tagging for a learning environment.

Unlike the current metadata models available, the discrimination tagging methodology is flexible, supporting individual authoring and development as well as reuse by multiple users, as the xsd can be created for individual use or shared and reused within the system. As described within this chapter, one main issue found with using xsds is that the instructors may use different tags to describe the same things. One technique that could be used to handle this complexity is global schematic mapping, which is used within the database community. Additionally this methodology offers the possibility of having learning objects that are tagged for numerous different types of discrimination, which is currently not possible with the available metadata models.

This discrimination methodology allows the instructor to author and tag learning content for learners, in order to facilitate or provide personalised learning content for the learner. This has the potential to offer the learner a more personalised learning experience within a familiar learning environment. The prototype implementation is not restricting a learner to one particular course but will allow them to search for available learning objects across a variety of subject domains, which is an advantage for the learner.

Allowing the possibility to view, select and save learning and assessment objects will enable the learner to manage their own learning. Allowing the learner to manage their own learning supports a heutagogic learning model, in which the learner makes selections from a range of resources according to criteria that they define to support their own learning. This is demonstrated within the Moodle implementation.

6 Experimental design

6.1 Introduction

The main purpose of implementing the Moodle extension prototype was to enable the evaluation of the ideas designed within the tagging methodology. The experimental design has been devised to test the prototype system and discriminatory tagging methodology in a number of ways.

Firstly, a critical reflection is described within this chapter that evaluates the personalisation and adaptability of the new Moodle enhancements compared to the original e-learning platforms evaluated within the research. This reflection was undertaken by the author and not by domain experts.

Next the author undertook a study to test the tagging search within the learning resource repository. The tagging methodology allows for instructors to author the learning content and for the learner to search for learning content. As far as this research is concerned it was decided that the main focus for the evaluation would be the instructors and how they author content. This is mainly due to the fact that other studies have previously evaluated the effect of the learner using learning content that is specific to their learning style, (Graf and Kinshuk, 2007, for example). Therefore, the study to test the tagging search facility is necessary to prove that it does provide material to learners based on the discrimination requirements, but the impact of these learning objects on the learners will not be evaluated.

Lastly studies were designed to evaluate the usability and tagging concept to be undertaken by domain experts from various disciplines. The experts worked through various tests including questionnaires as well as structured and cognitive walkthroughs. During the cognitive walkthrough the think aloud protocol was used. Additionally, an unstructured interview took place after the other tests are completed.

This experimental design chapter therefore describes how these studies have been designed and exactly what the studies have been designed to test.

6.2 The critical reflection

Chapter 3 Section 3.3.2 contains a description of an evaluation study undertaken within this research to evaluate the personalisation and adaptability offered by common e-learning platforms. The platforms evaluated were Blackboard, Intralearn, Angel, Saba, Moodle, A Tutor, Sakai, LRN and Ilias. The evaluation criteria are grouped within three categories and these categories are Functionality, Adaptability and Personalisation.

Extensive evaluation was undertaken and the outcome of this research showed that all the e-learning platforms evaluated offered some good tools for the instructor to manage courses and material and also some good facilities for the learner to view material for their courses. However, it was also found that the platforms evaluated offered very limited personalisation and adaptability for the learner. Figure 5 in Chapter 3 shows the outcome of this initial evaluation.

In particular, some e-learning platforms offered basic user interface personalisation and others offered a basic learning object search, but not much more than this was found within any of the platforms evaluated.

This first study was designed to undertake an evaluation of the extended Moodle incorporating the discrimination tagging to assess the extent to which personalisation and adaptability have been provided with the new extended system.

Therefore, the purpose of this test was to compare the extended Moodle prototype incorporating the discrimination tagging to the original Moodle evaluated. This evaluation uses the same evaluation criteria used within the research chapter. As mentioned previously, this criteria used extends the criteria that was proposed by Rego et al. (2007).

6.3 The tagging search in the learning repository study

These studies do not cover any pedagogical issues with regards to learning objects. It was felt that as many researchers (see Graf and Kinshuk (2007) discussed in Chapter 3 for example) have focused on this, it would be out of the scope of this particular project. However, it was felt that it is important to test the system to make sure that it does provide the learner with learning objects according to their needs.

The studies were run in Moodle and tested the output of the learning resource repository test function.

Two tests were devised for this and they were testing as a learner with VA learning style type and as a learner with RK learning style type. The test was devised to see whether the learner with VA type was provided with learning objects that are text, vodcast, PowerPoint slides (with and without audio), multimedia or podcast files and the learner with the RK type was provided with learning objects that are PowerPoint slides (without audio), text or multimedia files.

6.4 Walkthroughs and questionnaires

The walkthrough and questionnaire studies were devised to be taken by domain experts who are university academic staff from a variety of different subject disciplines, such as education, mathematics, computing and architecture. Twelve academics were chosen to undertake the main study due to the fact that they have an interest in e-learning.

The studies were devised so that the domain expert works through the studies in order and each expert was allocated the same amount of background information to help them with the tasks.

Initially, pilot studies tests took place with two other domain experts from computing disciplines with some interesting outcomes. These outcomes are as follows:

- Some feedback from these pilot cases was that the information given to the domain experts needed to be clearer at the beginning of the evaluation session. The background information as described in the next section was therefore amended and improved based on the feedback from the domain experts.

- Some minor issues with the interface were also highlighted during the pilot tests. These interface issues were therefore tidied up before the main studies took place.

- During the pilot runs the laptop used to run the extended Moodle was an Apple Mac laptop. This was raised as a possible issue during the pilot test as the domain experts to be used might not be familiar with an Apple Mac. The structured walk-through document was therefore improved to contain some helpful information for the experts that were not used to working with an Apple Mac environment.

When the domain experts undertook the structured and cognitive walkthrough studies, they were provided with a laptop running the enhanced version of Moodle incorporating the tagging concept. Some of the studies that they were asked to undertake were timed and recorded by the researcher.

The domain expert studies were therefore designed to take place in a sequence. This sequence was as follows:

1. Pre-study questionnaire
2. Structured walkthrough
3. Cognitive walkthrough
4. Post- study questionnaire
5. Unstructured interview

The background information given to the domain experts at the start of the session prior to the first questionnaire was as follows:

"*This research project is within the area of using tagging learning objects for personalisation and reuse. Research I have undertaken has shown tagging is underused in e-learning and that e-learning platforms offer little in the way of personalisation for the learner. The model created allows for the learning material to be personalised for the learner in a number of ways including their learning style, background knowledge and goals. The learning style used here is the Fleming's VARK learning style.*

The learning style representation in the system is based on the way the objects are tagged. Learning materials are provided to the learner based on their own learning style type. For example, a Visual learner may prefer a video, vodcast or PowerPoint slides and diagrams, figures and graphs.

The model concept has been created and part of it has been implemented in Moodle. This evaluation is to evaluate the Moodle extension and also the concept of the model.

Today you will be asked to complete an initial questionnaire then undertake 2 tasks. Task 1 will be a walk-through step-by-step of the system and task 2 will be a cognitive walk-through in which you will be set some tasks to do and will be expected to complete them on your own without a step-by-step guide. You will then be asked to complete a further questionnaire at the end. After this, we can have a more general discussion as I would be interested to get more feedback from you."

This background information gives the expert an overview of the methodology and the implementation. This information also gives them an overview of the studies that they will be asked to take during the session and the sequence of the studies.

6.4.1 Structured walkthrough

The main purpose of the structured walkthrough is to enable the domain experts to become familiar with the extended Moodle prototype and how to use the prototype to author and search learning objects.

The walkthrough document given to the expert is a step-by-step guide to completing the set tasks within the prototype. Just before the start of the structured walkthrough study the evaluators are given the following information:

"*This study is basically a walk-through of the system that represents part of the tagging model. Please try to remember the steps taken as you will need these for the next study. Please note that any questions and queries you have will be recorded*."

Full details about the two tasks involved in the structured walkthrough can be found in Appendix A.1.

As the domain expert works through both of the tasks, any questions or comments raised are recorded by the research accordingly.

6.4.1.1 Structured walkthrough task 1

Before this study takes place, the expert was given the following information:

"This system is an extension to Moodle for authoring and searching learning resources. The researcher will record any questions and comments that you have about the system."

Within task 1 the domain expert takes on the role of the instructor and adds a searchable learning object to the system. Instructions guide the domain user through the required steps to complete the tasks.

At the beginning of the task from the prototype Moodle start page the researcher showed the domain expert how to navigate to course topic page and how to set the page to editable. Setting the page to editable will allow for the expert to be able to upload an object and the corresponding tags.

Task 1 was the next task to be completed by the domain expert, and to be able to complete the task, a learning object was provided within a folder for the domain expert to upload. The task document gave instructions to the expert on how to upload the learning object. The experts were also provided with the tags for the learning object and they were required to add the tags for the learning object.

The tags they were asked to add for the learning object are:

- Title: Lecture 1
- Learning object
- Description: PowerPoint slides containing lecture 1
- Keywords: web, lecture 1
- University stage: 1st year undergraduate
- Difficulty: easy
- Resource type: lecture
- File type: PP slides (without audio)

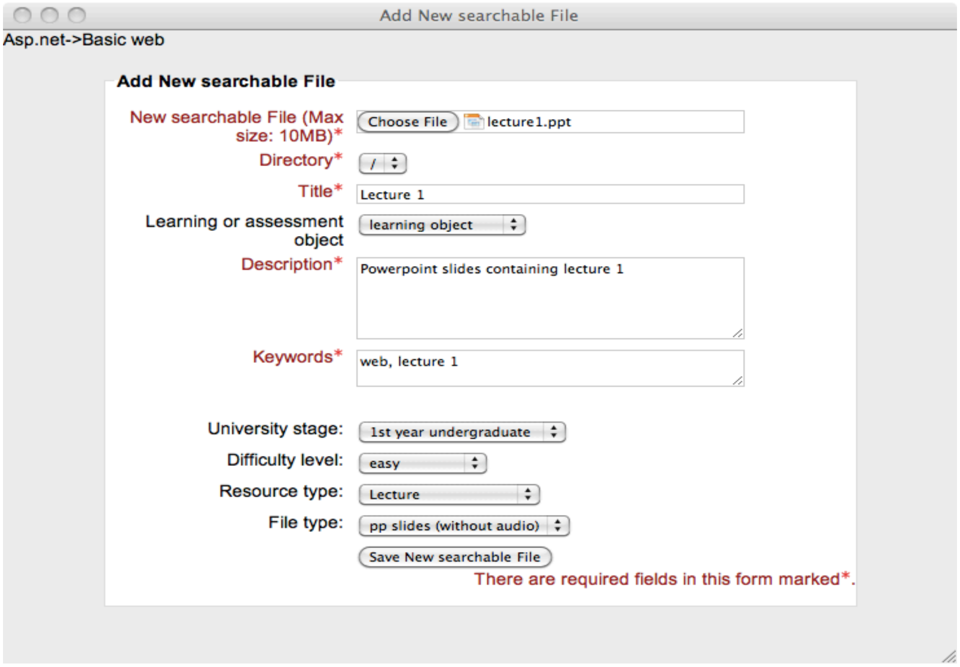


Figure 38: Example for structured walkthrough task 1

The window shown in Figure 38 gives shows the expert how the searchable window looks when completed for task 1.

6.4.1.2 Structured walkthrough task 2

Within task 2 the domain expert was asked to take on the role of the learner to search for learning resources based on individual criteria. The domain expert was given instructions for the required steps to complete the tasks. The steps include locating the learning resource repository and adding the appropriate tags.

During this task the domain experts were asked to search and select learning and assessment objects for an undergraduate year 1 learner with the VR learning style type as shown in the learning object search window in figure 39.

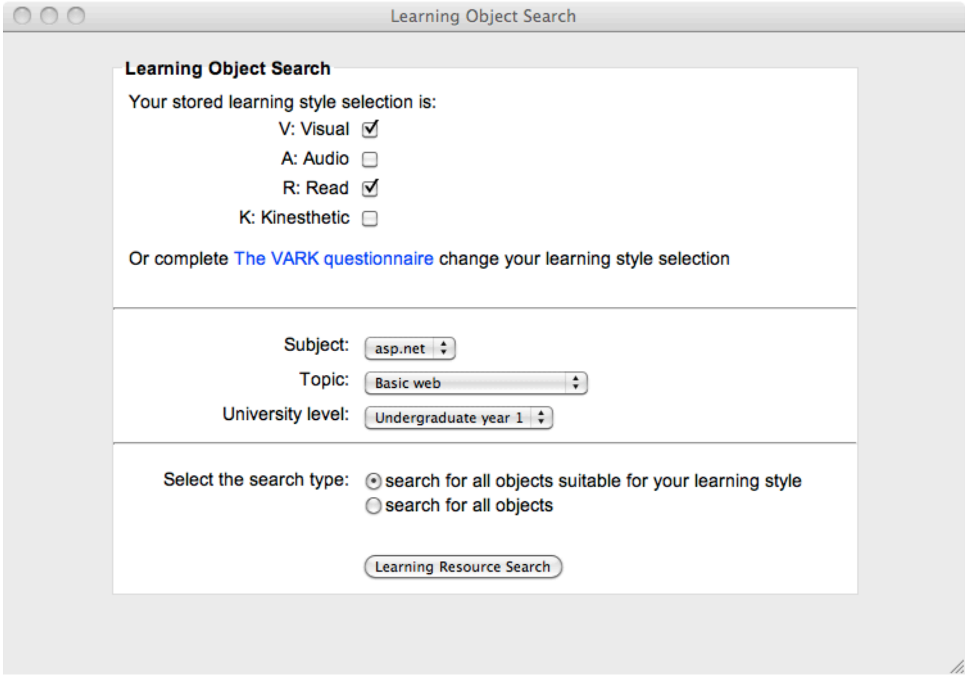


Figure 39: Learning object search window for structured walkthrough task 2

6.4.2 Cognitive walkthrough

According to Wharton et al. (1994) the cognitive walkthrough is a usability inspection method that focuses on evaluating a design for ease of learning, particularly by exploration. They state that this focus is motivated by the fact that many research studies have shown that many users prefer to learn software by exploration.

Additionally, Nielsen (1994) state that cognitive walkthroughs use a more explicitly detailed procedure to simulate a user's problem solving process at each step through the dialogue, checking if the simulated user's goals and memory content can be assumed to lead to the next correct action. This will be assessed for each expert during the cognitive walkthrough.

After the expert works through the structured walkthrough, the main purpose of this cognitive walkthrough study was to assess the usability of the implementation and to give the domain experts a greater understanding of the underlying tagging concept. The domain experts were asked to explore the prototype without guidance to complete the tasks.

The five main usability characteristics stated by Nielsen (1992) follow and the cognitive walkthrough will allow for these usability characteristics to be evaluated for the prototype.

- Learnability
- Efficiency of use once the system has been learned
- Ability of infrequent users to return to the system without having to learn it all over again
- Frequency and seriousness of user errors
- Subjective user satisfaction

The full cognitive walkthrough document can be viewed in Appendix A.2. The domain expert was expected to undertake these tasks using the knowledge of the system gained whilst undertaking the structured walkthrough study.

Before the cognitive walkthrough study, the domain experts were given the following information:

"For clarification, within this learning style, the learner could be any combination of learning style types. For example, someone could be AR and they would prefer resource types lecture simulation, narrative text, exercise, index, questionnaire, slide, table, exam and file types PowerPoint slides (with and without audio), text documents, multimedia or podcast.

Study 2 is basically similar to the previous structured walk-through. However, you are asked to undertake some tasks without guidance and you are given scenarios and you must undertake these tasks within Moodle.

Please undertake these tasks using the think aloud protocol. This method requires you to talk aloud and describe what you are doing and will be recorded."

Also before starting the study, the expert was also given a table showing the learning style file representation. This table was described to the expert and it shows the file type representation within the system. Further clarification was also given to the expert to ensure that they understood the information before starting the task.

The cognitive walkthrough consisted of two tasks. During both tasks the domain experts were requested to undertake them using the think aloud protocol. Using this protocol the domain experts were expected to talk through what they were doing and this was recorded for evaluation purposes.

Rogers et al. (2011) state that the think aloud technique requires people to say out loud what they are thinking and trying to do so that their thought processes are externalised. Additionally, according to van Someren et al. (1994) the think aloud protocol is a very direct method to gain insight into the knowledge and methods of human problem-solving and it is therefore thought that this would be a useful tool for this study.

The first task was authoring material and the second was searching for learning materials. Both of the cognitive walkthrough tasks was timed and the timing of this was analysed.

6.4.2.1 Cognitive walkthrough: Task 1

Once the domain experts had worked through the structured walkthroughs they were then asked to do the cognitive walkthroughs. The domain experts were given the laptop to use and were asked to work through the test without assistance from the researcher. For the authoring material task the domain experts were asked to author two types of learning objects for two different learners. The starting conditions for the experiment were that the study took place in an office where experts were provided with a laptop containing learning objects to choose from. The available learning objects were of different file types: PP slides (with audio), Multimedia, Podcast and Text and the corresponding tags for each learning object is also shown in Table 7. These learning objects cover a range of learning style types to enable the expert to select the appropriate one for the particular learner type.

The experts were also provided with a handout to work through describing the test requirements (shown in Appendix A2) and the location of the learning objects. The cognitive study was voice recorded and timed with a stopwatch by the researcher.

Therefore for this task, the domain expert was expected to select the appropriate learning material available (Table 7) for the following types of learners:

- A learner who prefers kinesthetic learning
- A learner who prefers read/write learning

File name	Title	Learning or Assessment object	Description	Keywords	Difficulty	Resource type	File type
WebLecture1.ppt	Lecture 1	Learning	Lecture 1 basic web	Basic, web	Very easy	Lecture	PP slides (with audio)
WebMultimedia1.html	Multimedia File 1	Learning	Multimedia 1 basic web	Multimedia, basic, web	Medium	Simulation	Multimedia
WebPodcast1.html	Podcast 1	Learning	Podcast 1 basic web	Podcast, basic web	Medium	Lecture	Podcast
WebExercise1.doc	Exercise 1	Learning	Exercise 1 basic web	Exercise, basic web	Difficult	Exercise	Text

Table 7: Available learning objects for task 1

The domain expert was asked to select the appropriate learning objects, upload the object and then add some given corresponding tags for the object.

6.4.2.2 Cognitive walkthrough: Task 2

For the search task the domain expert was asked to search and save learning objects for two different types of learners: one with the Visual learning style category and one with the Aural and Kinesthetic learning style category. The learners are at different levels and would like to search for the asp.net subject and the introduction to web forms topic.

The instructions for particular task given to the expert were as follows:

1. *You are an* ***Undergraduate Year 1*** *learner with the learning style category* ***Visual (V)****. You would like to search for some* ***asp.net introduction to web forms*** *learning resources suitable for your learning style preference. View and select a variety of suitable learning resources.*

2. *You are an* ***Undergraduate Year 2*** *learner with the learning style category* ***Aural and Kinesthetic (AK)****. You would like to search for some* ***asp.net introduction to web forms*** *learning resources suitable for your learning style preference. View and select a variety of suitable learning resources.*

Undertaking this task will enable the usability of the prototype to be assessed together with allowing the expert to gain a greater understanding of the methodology.

6.4.3 Questionnaires

Rogers et al. (2011) state that questionnaires are a well-established technique for collecting demographic data and users' opinions. They also argue that effort and skill are needed to ensure that questions are clearly worded and the data collected can be efficiently analysed.

Two questionnaires were devised for this evaluation, one questionnaire for the expert to complete before the walkthrough studies, and one for the expert to complete after the walkthrough studies.

The result of the questionnaires was used to evaluate the concept of the methodology developed and additionally to evaluate the usability of the prototype system and to receive feedback about the implementation in general.

The questionnaires test the prior knowledge of the domain experts and gave them the opportunity to evaluate the system and methodology.

6.4.3.1 Pre-study questionnaire

In this questionnaire the domain expert was asked the following questions and asked to rate them where '1' represents no experience and '5' represents expert:

1. How do you rate your experience with Fleming's VARK learning style?

   It was felt important to know this level of experience particularly as they are asked to author learning objects for a learner of a particular learning style type. It was thought that there should be a mix of levels with this as some may have very little experience and some may have expert experience.

2. How do you rate your experience generally of tagging objects?

   As the concept of tagging is paramount to the methodology and therefore it was felt important to assess the domain expert's experience of this before undertaking the walkthrough. It was felt that most of the domain experts should have some experience of tagging objects particularly within social media.

3. How do you rate generally your current experience with e-Learning Platforms?

   It was felt that this was an important question. It was expected that most of the domain experts would have experience of e-learning platforms. However, the level of experience was expected to vary.

4. How do you rate your current experience with Moodle?

   Although it was expected that most would have experience of some e-learning platforms, the researcher was unsure how many will have experience of Moodle.

5. If you have used Moodle before how do you rate your experience with Moodle to author online material?

   It was felt important to know how many have this experience as they may just have experience of using it from a learner side.

6. How do you rate your experience in using other tools to author online material?

   This experience would be useful and they were asked to provide information about other authoring tools that they have experience of.

The results of this questionnaire were very useful when evaluating the outcome of the other tests and also the unstructured interview.

6.4.3.2 Post-study questionnaire

The post-study questionnaire enables the evaluation of the usability of the system, the main concepts within the methodology and also the Moodle implementation.

The expert was asked to state whether they strongly agree, agree, OK, disagree or strongly disagree with each question.

The questions asked were as follows:

1. The system is easy to use.

2. Using the system enabled me to gain a greater understanding of Moodle.

3. Tagging learning material within e-learning and Moodle is useful.

4. The ability to re-use learning material within an e-learning platform environment is helpful to users.

5. This is potentially a useful enhancement to Moodle.

6. Tagging increases the potential for the personalisation of learning materials for learners within e-learning.

7. As an instructor, a system incorporating learning styles is interesting to me and I can see a benefit to this.

8. Personalisation of learning material to suit different users is useful.

9. If a system similar to this incorporating tagging learning material was available I would use it.

The questions 1 and 2 were structured to evaluate the usability of the prototype system. The other questions were structured to evaluate the methodology and also the Moodle enhancement. The methodology questions cover tagging and learning styles and the concept of personalisation of learning materials. This enables the experts to give feedback about the methodology and implementation in a structured way, which was then analysed.

It was also felt that it would be beneficial to do a comparison of both the pre-study and post-study questionnaires for each domain expert to see the correlation between them. In particular to see whether an expert's prior knowledge within an area affects their responses to the post-study questionnaire.

6.4.4 Unstructured interview

Rogers et al. (2011) state that an advantage of using unstructured interviews is that they generate rich data that is often interrelated and complex. For example, data that gives a deep understanding of the topic. In addition, they state that interviewees may mention issues that the interviewer has not considered.

The purpose of the unstructured interview was to get informal feedback about the methodology and system from the expert in an unstructured way. The experts were asked open questions within the interviews so that there was no format or structure to the answers.

It was felt that it was important to do the unstructured interviews after all other studies have taken place (including the post study questionnaire) so that the other study results were not affected by the interview discussion.

Therefore, the main reason for this unstructured interview was that it was felt that it would be a good way to get further information from the domain experts. For example, how they could see this methodology extending into other areas or to discuss any possible issues that they find with it.

During the interview they would also have an opportunity to expand their feedback about the methodology itself. It was thought that each of the experts may have knowledge in different areas and therefore they may have different views on the concepts of the methodology and the prototype.

The unstructured interview was also noted and recorded and the discussion was transcribed, evaluated and analysed as part of the evaluation results and analysis.

6.5 Summary

The studies described within this chapter were devised to test the discriminatory tagging methodology defined within the hypothesis. The study design described was undertaken for the evaluation part of the objective “to create and evaluate a model to offer personalised learning based on a learner’s learning style” as set out in the introduction of this thesis. It was felt that systems incorporating learning styles have been evaluated for the learner view in other studies (Graf and Kinshuk, 2007, for example) and therefore it was decided that this evaluation would concentrate on the instructor side of the tagging methodology.

Focusing on the instructor side led to the hypothesis being revised and therefore it was revised to be, "a discriminatory tagging methodology for authoring content can be developed to personalise learning materials to an individual learner".

Described within this chapter are the different data capturing techniques that were designed for the evaluation. The sequence of the methods used allow for both the tagging methodology and the prototype implementation to be evaluated.

The critical reflection enables the personalisation and adaptability of the prototype to be compared with common e-learning platforms. These common platforms have limited personalisation and adaptability for the learner at present.

The testing of the search functionality within the learning resource repository should demonstrate that the system does what it is supposed to do, which is to provide learning objects to a learner based on the tag set. Any pedagogical issues relating to these are then outside the scope of this project.

The domain expert studies were devised for the academic staff of different disciplines who will have different knowledge and understanding about e-learning and tagging.

Moodle has leant itself as the development tool, though the purpose of this development was to be able to evaluate the concepts within the methodology. Working through the walkthrough studies gave the domain experts a good understanding of the methodology together with an understanding of how the prototype was developed.

The structured interview stage of the session was devised to be able to provide some interesting results. Those experts with a good knowledge of Moodle were given the opportunity to feedback specifically about the development during the structured interview. Those experts with a good knowledge of tagging were given the opportunity to feedback specifically about concepts within the tagging methodology and perhaps discuss ways that this may be taken forward.

The data collected during these study sessions was collected and analysed. This data and analysis will be discussed within the next chapter within this thesis.

7 Results and analysis

7.1 Introduction

The results and analysis presented in this chapter are the results of the studies described within the previous experimental design chapter. These results come from a sequence of tests some of which use domain experts in order to evaluate their view of the methodology and the prototype implementation.

The first part of this chapter is a critical reflection that will compare the extended Moodle prototype incorporating the discrimination tagging to the original Moodle evaluated in Chapter 3. This evaluation will use the same criteria used within the research chapter, which is one that extends the evaluation criteria proposed by Rego et al. (2007).

The next part of the chapter is the results of testing the search functionality. This will test the discriminatory tagging to see whether the appropriate learning objects are provided to the user, and will test the tagging concept, rather than any pedagogical factors relating to learning styles.

The expert evaluation results then follow. The results described within this chapter are the findings of the data analysis of various data capture techniques including questionnaires, cognitive walkthroughs (using the think aloud protocol) and unstructured interviews. A frequency analysis is also described using the Wordle (Feinberg (2009)) tool to find common words within the study transcripts. These data capture methods are described in detail in the previous experimental design chapter.

7.2 Critical reflection

Chapter 3 describes an evaluation study undertaken within this research to evaluate the personalisation and adaptability offered by common e-learning platforms. The platforms evaluated were Blackboard, Intralearn, Angel, Saba, Moodle, A Tutor, Sakai, LRN and Ilias. The evaluation criteria used were grouped within three categories and these categories are Functionality, Adaptability and Personalisation.

As described in Chapter 3, the outcome of this research evaluation was that it was found that all of the platforms evaluated offered a number of good tools for the instructor to manage courses and material and also some good facilities for the learner to view material for their courses. However, it was also found that all of the platforms evaluated offered very limited personalisation and adaptability for the learner.

This critical reflection is therefore an evaluation of the personalisation and adaptability of the new enhanced Moodle incorporating tagging using the same criteria as the evaluation described in Chapter 3.

The next part of this chapter describes the critical reflection results for each criteria and the scoring justification in detail. The scoring is described in Chapter 3 as 0: none, 1: some but limited, 2: good and table 5 provides a summary of the results.

F1: Instructor can manage course material and sequence

There is no change found with this score. The original Moodle was found to have good facilities for instructors to manage course material and sequence the material. The facilities are the same with the enhanced Moodle.

F2: Instructor can manage and monitor learners

No change found with this score. The original Moodle was found to have good facilities for instructors to manage and monitor learners. The facilities are the same with the enhanced Moodle.

F3: Learner is able to search for learning objects

The original Moodle evaluated was not found to have a learning object search facility available. The enhanced Moodle incorporating tagging provides the learner and instructor with a search facility for learning objects. They are able to search for objects based on their own specific requirements and also are able to search generally for all objects. This therefore allowed for a score of 2 for the Moodle with tagging for this section.

A1: Adapt to learner's goals

The original Moodle evaluated was not found to adapt to learner's goals and so therefore gained a score of 0. The enhanced Moodle incorporating tagging is able to adapt to the learner's goals by providing learning material based on their self-specified goals. The score therefore for A1 for the enhanced Moodle with tagging is 2.

A2: Adapt to learner's behaviour

Both the original Moodle and the Moodle incorporating tagging do not adapt to the learner's behaviour as this is outside the scope of this research project. However, this would be advantageous for an adaptive e-learning system. This could therefore be a possible future enhancement for this system. The score therefore for A2 for the enhanced Moodle with tagging remains at 0.

A3: Adapt to learner's learning style

The original Moodle evaluated did not adapt in any way to the learner's learning style. The Moodle incorporating tagging does adapt to the learner's learning style. The system allows for content to be provided that is suitable for the user's own particular learning style. This learning style is stored in the system and can also be updated when required. The score therefore for A3 for the enhanced Moodle with tagging has changed from 0 to 2.

P1: User Interface personalisation

No change found with this score. The original Moodle was found to have good user interface personalisation capabilities. The interface personalisation capabilities are the same with the enhanced Moodle.

P2: Learning content specific to their specific learning need

The original Moodle evaluated did not provide learning content specific to their learning need. The Moodle incorporating tagging provides content specific to their learning need, including their subject/topic preferences and learning level requirements.

The score therefore for P3 for the enhanced Moodle with tagging has changed from 0 to 2.

P3: Learning object type specific to their specific learning needs

The original Moodle evaluated did not provide learning object types specific to their learning need. This is provided in the Moodle incorporating tagging as it provides the object of a particular object type based on the learner's learning style. The score therefore for P3 for the enhanced Moodle with tagging is 2.

P4: Course structure according to their specific requirements

The original Moodle evaluated did not provide course structure according to their own specific requirements, only an inflexible course structure for all. The Moodle incorporating tagging allows for the learner to select specific learning objects and therefore it could be extended to provide the learner with their own course structure. The score therefore for P4 for the enhanced Moodle with tagging is 1 as this could be developed as an extension of the current system.

Criteria	Moodle original	Moodle with tagging
F1: Instructor can manage course material and sequence	2	2
F2: Instructor can manage and monitor learners	2	2
F3: Learner is able to search for Learning objects	0	2
A1: Adapt to learner's goals	0	2
A2: Adapt to learner's behaviour	0	0
A3: Adapt to learner's learning style	0	2
P1: User Interface personalisation	2	2
P2: Learning content specific to their specific learning need	0	2
P3: Learning object type specific to their specific learning needs	0	2
P4: Course structure according to their specific requirements	0	1
Total	6	17

Table 8: Showing Moodle scores before and after tagging

It was found, therefore, that the final score for the enhanced Moodle with tagging was 17 and this is substantially more than the 6 given for the original Moodle evaluated and a summary of the results are in Table 8. The enhanced Moodle with tagging gained scores in all aspects apart from adapting to the learner's behaviour, which was outside the scope of this project. Additionally, the mark was lower for the course structure personalisation criteria due to the fact that chosen objects are grouped all together within the system rather than put as separate courses. The enhanced Moodle system therefore offers the instructor the capability to author learning objects that will enable the learner to have more of a personalised learning experience.

7.3 Testing the tagging search in the learning resource repository

Tests were run to track the output of the learning resource repository to test whether the correct learning objects were provided for the specific type of learner. The learning objects provided should correspond to the object and mapping shown in Chapter 4 in Table 4. The main purpose of this test was to test the tagging concept to see that the correct learning objects are provided rather than the learning styles and pedagogical factors.

The tests were run for two different types of learners, one with the learning style type VA and one with the learning style type RK.

7.3.1 User with VA learning style type

In the main learning repository search screen, visual and audio were selected for the learning style type, asp.net and introduction to web forms as the subject and topic and undergraduate year 1 as the level. This is demonstrated in Figure 40.

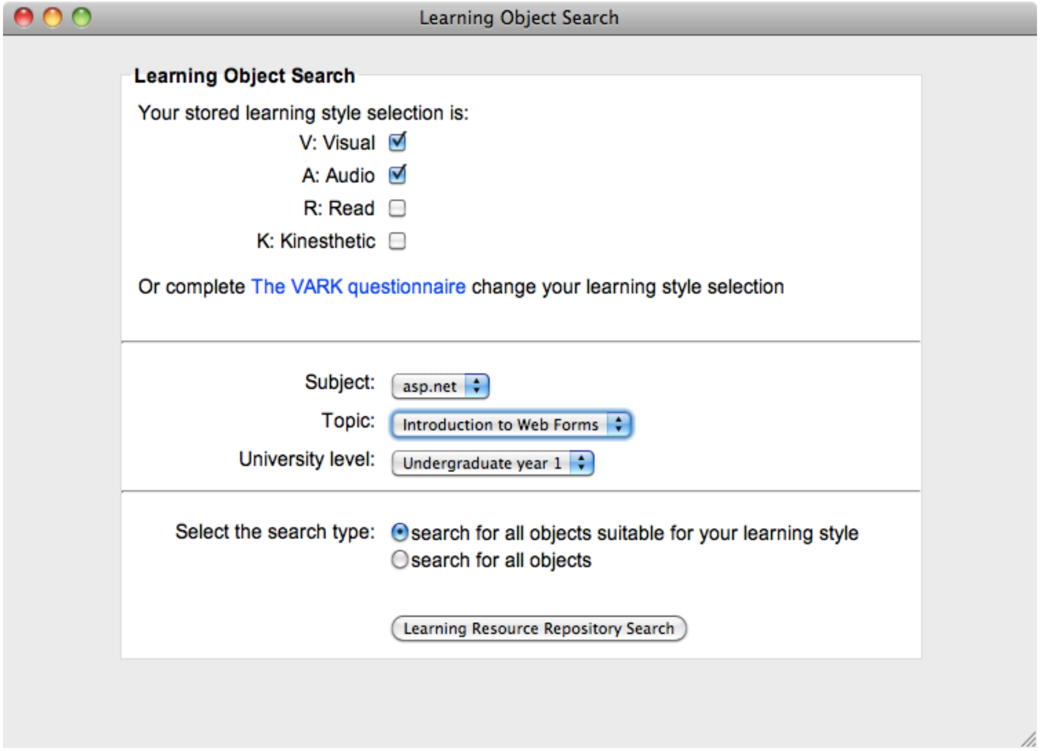


Figure 40: Search screen for user with VA learning style type

The results for this search test as shown in figure 41:

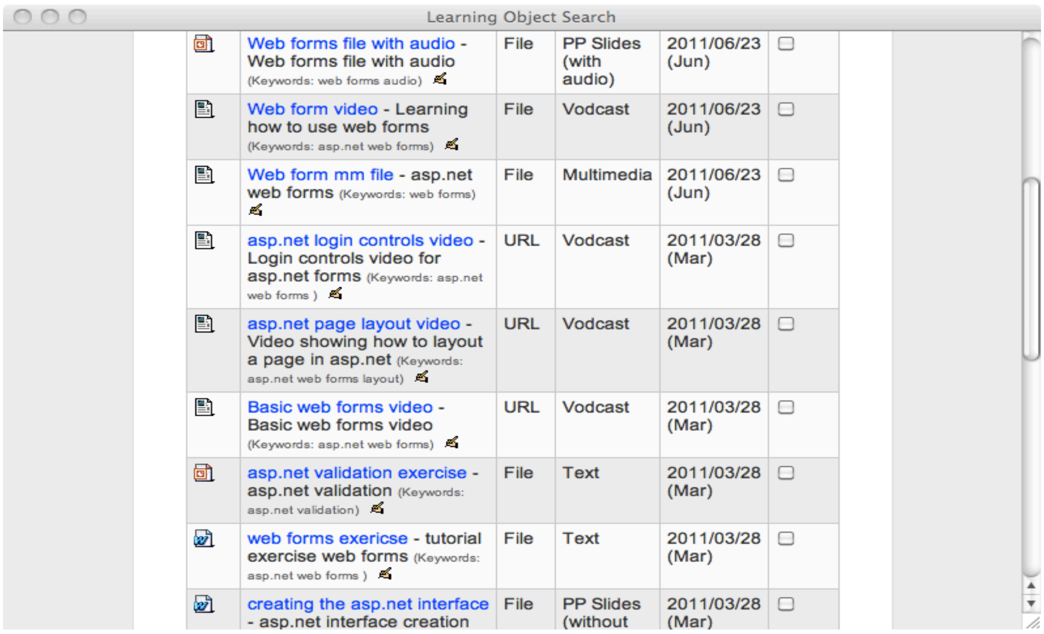


Figure 41: Search results for user with VA learning style type

The results were expected and show the learning objects have been provided for the learner, which are suitable for the learner specific requirements:

All objects are tagged with the following:

- Asp.net and introduction to web forms as the subject and topic
- Undergraduate year 1 as the level

Objects have one file type as follows:

- PP Slides (with audio) – audio learning style type
- Vodcast – visual learning style type
- Multimedia – aural learning style type
- Text – visual learning style type
- PP Slides (without audio) – visual learning style type

7.3.2 User with RK learning style type

In the main learning repository search screen, read and kinesthetic were selected for the learning style type, asp.net and introduction to web forms as the subject and topic and undergraduate year 1 as the level. This is demonstrated in Figure 42.

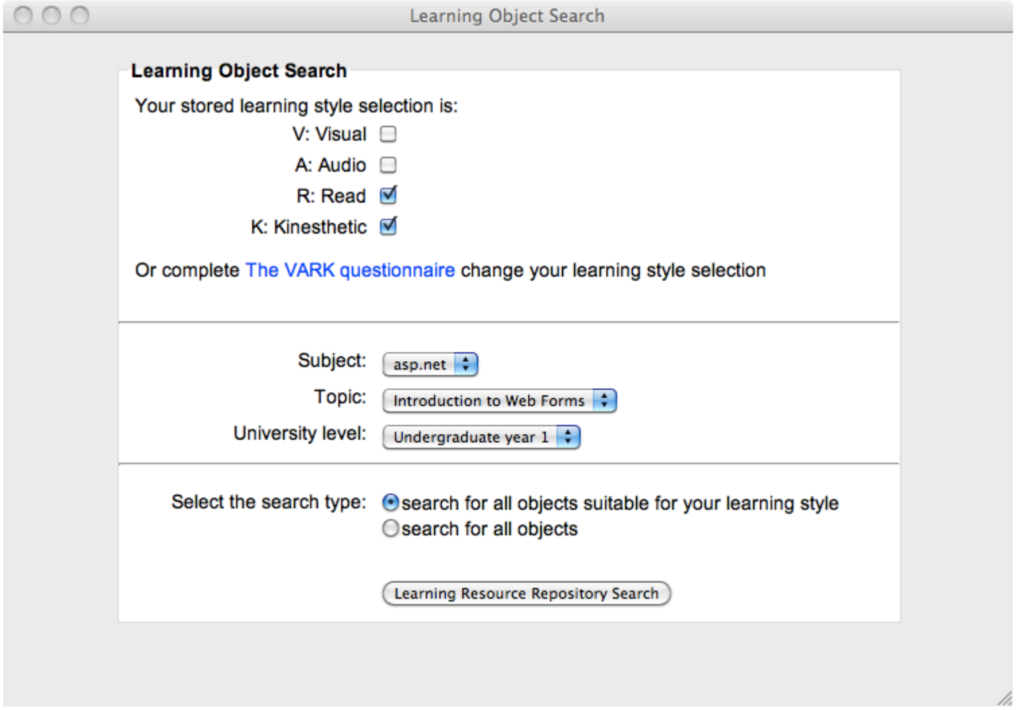


Figure 42: Search screen for user with RK learning style type

The results for this search test as show in figure 43:

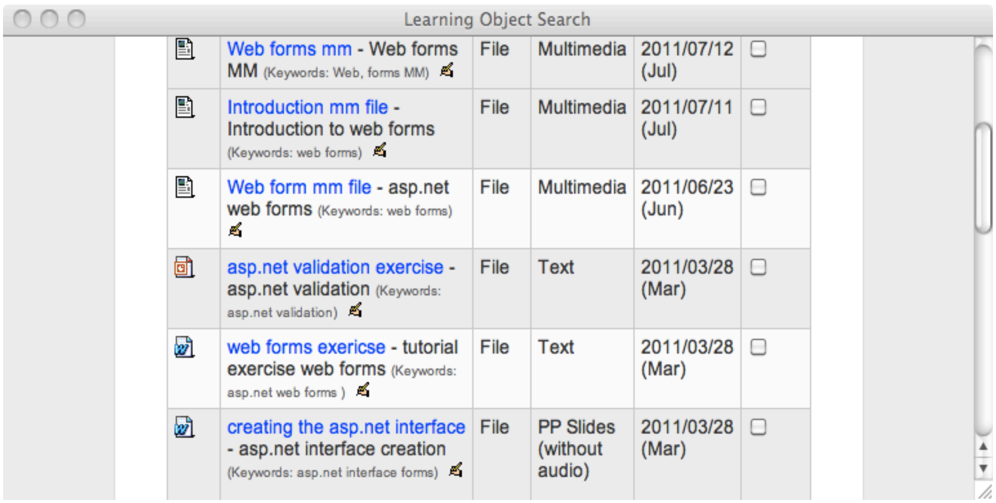


Figure 43: Search results for user with RK learning style type

The results were expected and show the learning objects have been provided for the learner, which are suitable for the learner specific requirements:

All objects are tagged with the following:

- Asp.net and introduction to web forms as the subject and topic
- Undergraduate year 1 as the level

Objects have one file type as follows:

- Multimedia – Kinesthetic
- Text – Read/write
- PP slides – Read/write

These tests demonstrate that the appropriate learning objects are provided to the learner based on their own specific learning styles. It does not test the pedagogical impact of these learning styles tags, as this has already been undertaken within a number of research projects, for example Graf and Kinshuk (2007). This study is described in chapter 3, and within this they provide some learning content for learners based on the Felder-Silverman learning style model and evaluate the learner side of the tagging concept. The result of the study was to find that the adaptability provided a positive effect. Due to these previous studies, it was decided not to concentrate of this for the purposes of this research and it was decided to concentrate on evaluating the tagging for authoring learning objects.

7.4 Expert evaluation

In the previous section, the tests described demonstrated that the system provides learning objects to the learner based on the given search criteria. Therefore the pedagogy impact of using this system is not being assessed as it has been assessed and evaluated before, for example Graf and Kinshuk (2007) who evaluate the impact of learners using the Felder-Silverman learning style model in an adaptive model within an e-learning platform with positive results.

This section describes the results of the expert evaluation. This expert evaluation was undertaken by 12 experts and is testing the implementation and the concepts of the tagging methodology and not specifically the learning styles, although some comments made by the instructors about learning styles have been recorded and discussed within this chapter.

As described in detail in the previous chapter, the expert evaluation studies have been designed to take place in sequence. This sequence is as follows:

- Pre-study questionnaire
- Structured walkthrough
- Cognitive walkthrough
- Post-study questionnaire
- Unstructured interview

The data analysis results within this section have been taken from all of these methods and have been categorised as interface design, tagging content, Moodle, authoring learning objects, tagging for learning styles, task timings and the frequency analysis of the transcription of the tasks. These data analysis results for these categories will now be described in detail.

7.4.1 Interface design

From the analysis of the post questionnaire it was found that all but one evaluator found the system easy to use. The evaluator that did not find the system easy to use had some experience in Moodle and made the comment that he felt that the system could be made simpler and he felt that at one point he found that two steps are required where one might be enough. This evaluator is a computer scientist and knowledgeable about HCI and therefore this was good feedback to receive.

Although a high percentage stated that the system is easy to use, some usability issues were raised by the evaluators whilst undertaking the tasks and during the unstructured interviews. For example, some highlighted that the save button is not really obvious as it is necessary to scroll down to find it. Others commented that the form in the middle is a bit ‘clunky’. Also, a problem with file duplication was found and it is felt therefore that more validation is required. All of these issues are fairly basic and would be relatively easy to sort out.

As far as completing the tasks are concerned, most managed to complete the tasks correctly. However, two evaluators did not select correct objects for the appropriate learning style, although all other evaluators managed and selected the appropriate files.

Some of the evaluators suggested some improvements to the interface. One suggestion was to allow for a number of levels for the learning object (for example, a learning object could be both final year and masters). Also, once an instructor has selected whether it is a learning or assessment object, the learning resource type choices then change to reflect this. These would be minor changes that could be made easily within the system.

7.4.2 Tagging content

Overall six of the experts stated that they had no experience of tagging and out of these five of them agreed that tagging content in Moodle is useful and four of them strongly agreed that tagging increases the potential for the personalisation of learning materials in e-learning.

Three evaluators stated that they had expert knowledge of tagging. For this group of evaluators, two said they strongly agree that tagging learning content in Moodle is useful and two also strongly agreed that tagging increases the potential for the personalisation of learning materials in e-learning.

A comment from an evaluator during the unstructured interview was that they felt it could be an issue that the instructors and learners need to know what the tags mean as it could be very subjective (for example the level definition for the learning objects). This is a very valid point and the system currently gets round this by offering fixed searchable tags rather than allowing the instructor to add free tags to be searched.

7.4.3 Moodle

Six experts stated that they had no or very little experience with Moodle. Of these experts, three said that they strongly agree and two agreed about the tagging ability being a potentially useful enhancement to Moodle. Five also agreed that this study enabled them to gain a greater understanding of Moodle.

The evaluators with the most experience in Moodle all strongly believed that this tagging ability is a potentially useful enhancement to Moodle.

Other comments that were discussed in the unstructured interview were that one evaluator highlighted that in their opinion it is difficult to get students to engage with Moodle anyway and the more we want them to do the less they want to use it and was worried that this system may be too complicated for students to use. This evaluator was therefore very skeptical about whether they would want to use the search facility.

7.4.4 Authoring learning objects

Six evaluators also said that they had little or no learning object authoring experience. These evaluators either strongly agreed or agreed that personalisation of learning material to suit different users is interesting. Of the evaluators with good or expert authoring experience two strongly agreed and one selected OK for this question.

Six evaluators said that they had no experience of using VARK, although they all strongly agreed or agreed that as an instructor a system with learning styles is interesting to them. The VARK expert evaluator also strongly agreed that as an instructor a system with learning styles is interesting to them.

59% of the evaluators strongly agreed and 33% agreed that the ability to re-use learning material within an e-learning environment is helpful (see Figure 44).

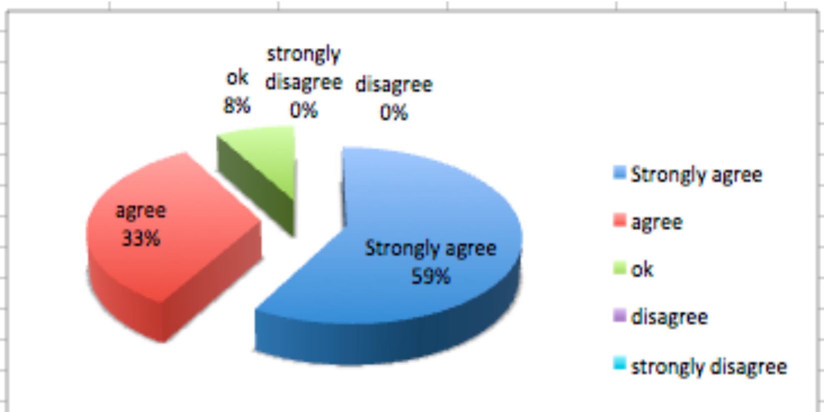


Figure 44: Results for question: "the ability to re-use learning material within an e-learning environment is helpful"

The evaluators were asked if they would use a system like this would they use it. 34% strongly agreed and 50% agreed (see Figure 45). The evaluator that selected OK for this was worried about the fact that tagging material for learning styles could be a negative thing and restrict them. The evaluator that disagreed and stated that he would not use the system if available was the evaluator that took the longest over the tasks and had an issue with working with the Mac environment.

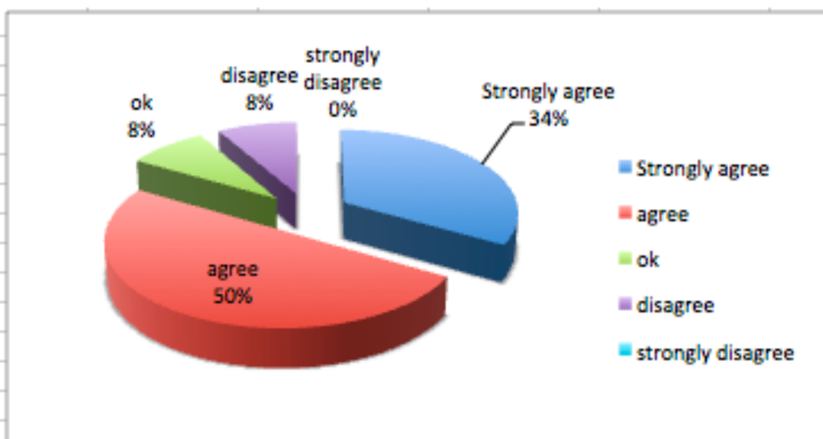


Figure 45: Results for question: "if a system like this was available I would use it".

7.4.5 Tagging for learning styles

The VARK learning style was selected as an example of tagging for discrimination. The background research demonstrates that there are criticisms about learning styles and the main focus of this project is not to prove or disprove these criticisms.

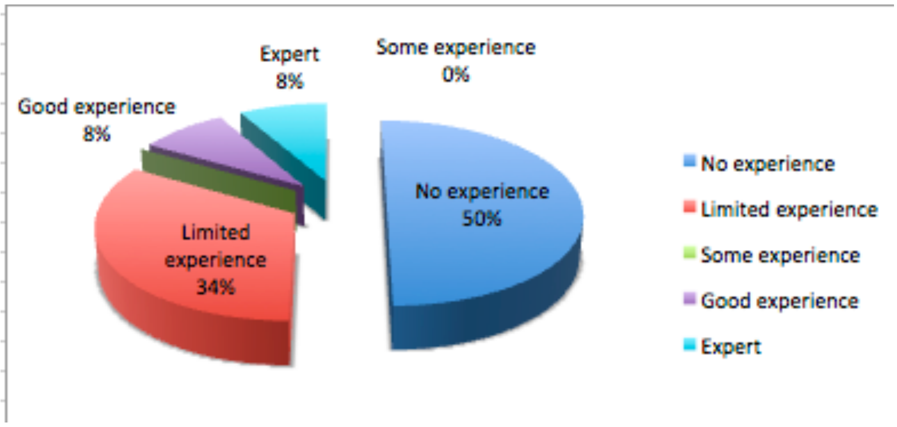


Figure 46: results for question: "how do you rate your experience with VARK?"

As far as the questionnaires are concerned, 50% of evaluators stated they had no experience with VARK and 34% said that they had limited experience (see Figure 46). Within the post-evaluation questionnaire, all of the evaluators either strongly agreed or agreed with the following statement "As an instructor, a system with learning styles is interesting to me".

Learning styles, however, were discussed during the unstructured interviews and comments were negative and positive, which was expected due to the fact that this is was found during the research into learning styles for this project. Sample comments from the evaluators about learning styles were as follows:

- "They will restrict the student from viewing potentially useful information."

- "Very useful to offer learners material appropriate to their learning style."

- “Encouraging students to view material based on their learning styles would benefit them.”

- “It is good to offer material based on learning style. However, it depends how motivated the learner is as to how much benefit will be gained.”

- “It is a bit of a luxury to be able to offer material based on a learner’s learning style.”

- “Tagging material for learning styles could be a restrictive thing as this may restrict them.”

- “Learning styles mean learners are thinking about their learning which is always a good thing.”

These comments are interesting as they are a real mix of views and opinions reflect the findings of the research into learning styles within Chapter 2. As mentioned previously, this research is not concerned specifically with learning styles and their usefulness. Learning styles are used within this project as an example discriminatory type to demonstrate the tagging ability.

7.4.6 The tagging methodology

One outcome of the evaluation was that it was difficult to differentiate the method from the delivery mechanism. It was found during the evaluation was that it doesn’t matter what the delivery mechanism is, as long as the tagging search is implemented then the delivery mechanism will look the same. This was seen during the implementation stage as both the Moodle implementation and C# implementations look very similar to the user. Therefore irrespective of the delivery mechanism what the user will see will be the same therefore comments of the experts on the outcome of the methodology are not dependent on the delivery mechanism.

However, during the evaluation, the experts made various comments specifically about the tagging methodology. Many experts stated that the concept of the methodology for tagging is useful; however, one expert stated that in their opinion it would be really good if this tagging methodology was to be used not as a replacement but as an extension to the traditional course material. Also, a positive comment came from an evaluator who stated that he felt it was really useful to be able to author learning content to suit a user's specific need.

Another comment from an expert during the unstructured interview was that they felt it could be an issue that the instructors had to create the tags, as it could be very subjective if based on one instructors view. This is possibly one weakness for the methodology as it is down to the instructor to devise and set the appropriate tags.

A further comment by an expert about the methodology concept was an issue that students may be restricted if they are only shown material based on the discrimination tags. The worry highlighted here was that students might not be shown material that could be really useful to them. This issue was actually addressed within the implementation of the system, as learners are allowed to also search for all learning objects, not just ones based on their learning styles.

Another comment from an expert was that some instructors may find using the discriminatory methodology for authoring learning objects daunting and another expert highlighted that it could be very time consuming to provide material for different types of learners. An issue with workload issues was raised by another expert, as there was a concern that using this methodology would greatly increase the workload for an instructor.

During the unstructured interviews, other evaluators suggested improvement or further development with the methodology as follows:

- That it could be used by students as an aid to feedback with searchable tags on material that instructors wish learners to view.

- It could be useful for the user to tag learning objects themselves. This concept is similar to social tagging.

- One evaluator said that he felt it would be really good to be able to make the keywords searchable within the system to enhance the current search functionality.

7.4.7 Task completion times

The cognitive tasks were timed and the results were recorded and the recorded times for the tasks is shown in figure 47.

In order to compare with the time the experts take for the tasks, the author undertook a pre-study task test resulting in the following timings for the tasks:

- Task one: 2 minutes 05 seconds
- Task two: 1 minute 01 second

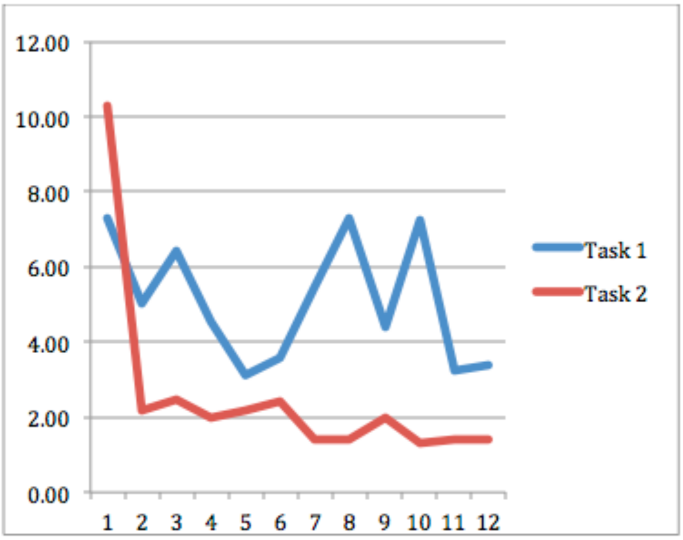


Figure 47: Total time taken for tasks 1 and 2

The pre-study tasks times are lower than the average time taken to do both of these tasks. See Table 8 for the comparison of this with the average time for each task.

	Task 1	Task 2
Pre-evaluation test time	2m 5s	1m 1s
Average time took by evaluators	5m 9s	2m 54s

Table 9: Comparison of pre-study time and average time taken by evaluators

The results of the tests showed that task one had a big variation of times from 7 minutes 30 seconds to 3 minutes 12 seconds. The pre-evaluation test was 2 minutes 05 seconds and so therefore all experts took more time than the pre-evaluation test. However, the results show that compared to the pre-evaluation test, the experts did not take an unreasonably long time to complete the tasks.

The first expert took more time than any others during the tasks. The timings for this expert were 7 minutes 30 seconds for the first task and 10 minutes 30 seconds for the second task. This evaluator had a general issue with working within an Apple Mac environment and therefore this resulted in the higher times for the tasks.

The expert who had the slowest time for task 1 actually stated a good knowledge of Moodle and therefore it shows that a previous knowledge of Moodle is not particularly important to be able to complete the exercises.

The three evaluators with the slowest time (7 minutes and above) for task 1 are all from the education discipline. Out of the four fastest evaluators for task 1, 3 are from the computer science discipline.

Apart from the evaluator who took 10 minutes 30 seconds for task two, all others took a small range of times from 1 minute 30 seconds to 2 minutes 49 seconds. The pre-evaluation test for task two was 1 minute 01 second and therefore all evaluators took more time than this and again this was expected.

These results were mainly as expected; all of the evaluators took more time than the pre-evaluation test. However, and most instructors completed the tasks within a reasonable amount of time. The one anomaly was the evaluator who took over 10 minutes in task one due to issues related to using a Mac. It can therefore be deduced from these results that the interface is fairly simple to use and is easy for the instructors to remember the steps for a task.

7.4.8 Frequency analysis

The observation and transcripts of the evaluators using the think aloud method whilst doing the cognitive walkthrough tasks and transcripts of the unstructured interview were collated. These were then put into Wordle to produce a frequency analysis of responses.

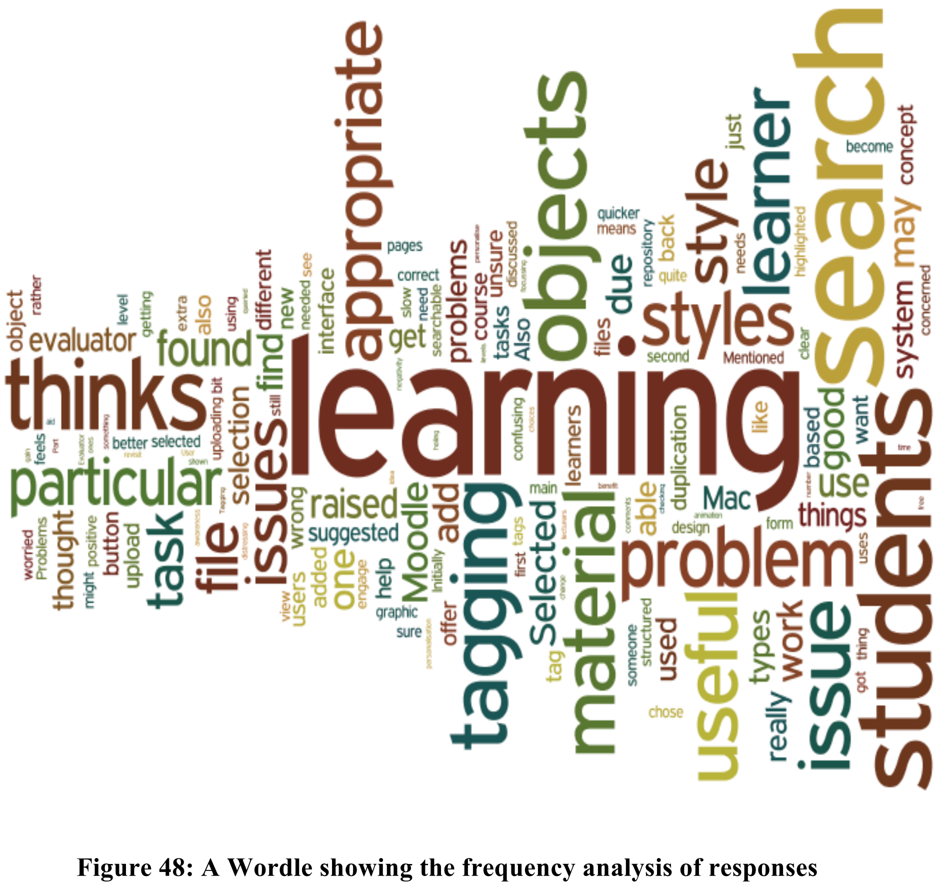


Figure 48: A Wordle showing the frequency analysis of responses

McNaught and Lam (2010) state that their experiences in using Wordle to inform research has led them to suggest that word clouds can be a useful research tool to aid educational research. Within their research, they have demonstrated also that they can allow researchers to quickly visualise some general patterns in text. However they also point out some limitations, which are that the words are retrieved out of context and therefore it is necessary to go back to the original text for clarification of the context. Wordle is felt to be a useful tool here, as the grouped words will be evaluated further within their context. The frequency analysis of responses in Wordle is shown in figure 48.

The frequency analysis provided by Wordle highlights common concepts and themes within the transcript and observation text. The prominent words that seemed most relevant and required further investigation were:

- Tagging
- Appropriate
- Issue(s)
- Problem
- Useful

The transcript and observation notes will be evaluated further to put these words in context to see why they were discussed and the issues that they raise.

Tagging

The transcript and observation notes show that the evaluators mention "tagging" in the following context:

- "Tagging appeals to me but not sure how I would make this work"
    - The expert said that his preferred learning style choice would be Honey and Mumford. The expert said that this was due to the fact that most of the work he does is reflective. He said that tagging would work ok with this – active (doing) reflective (thinker) pragmatist (applying what they've learnt) for example.
- "The concept of tagging is useful".
    - The evaluator said that it may be particularly useful for the users to tag the learning objects themselves.
- "Staff may not be able to do this tagging due to work-load and other issues".

- The evaluator said that instructors may not want to do any tagging at all or if they do they may not add particularly useful tags.

- "I feel that tagging material for learning styles could be negative experience and it may restrict them".
  - The evaluator raised this issue because they say they cant do other things and think they should develop their own awareness of what they can and can't do and then build on it from there.

Further analysis of these comments show that the comments raised and discussed are not particularly positive about tagging which is in contrast to the questionnaire responses that were generally very positive.

These negative comments were mainly coming from concerns about how the instructor will use tagging, whether they would be able to use it and whether it is going to add to their workload. Another negative comment was about the subjective nature of the tags and what they actually mean. Also, who defines the meaning of the tags? This was a concern highlighted within the background research of the project by Li and Lu (2008) who found that one of the challenges in tagging systems are the inconsistency and ambiguity of tags.

Appropriate:

The transcript and observation notes raised "appropriate" in the following context:

- During the observations, it was observed on a number of occasions that the tags were entered appropriately by the evaluators.
- Evaluators uploaded and searched for appropriate objects.
- One expert said "File types should be more appropriate".
- During the observations, the experts chose appropriate objects.
- During the observations, the experts selected appropriate objects.
- One expert thought that "It would be useful to offer learners material appropriate for their learning style".

These comments generally come from the observation of the experts undertaking the tasks and show that the instructors added tags appropriate for the particular objects. This shows that the system was intuitive for the experts to use as most were able to enter the appropriate tags. Likewise, these comments also showed that the instructors searched for appropriate objects when undertaking the search task.

Issue(s):

The transcript and observation notes raised "issue(s)" in the following context:

- During the observations, an issue was found with a file upload due to a Mac user problem.
- An expert said, "An issue is that it is difficult to get students to engage with Moodle generally (the more we want them to engage the less they want to)".
- An expert said, "Teaching staff may not be able to do this tagging due to workload and other issues".
- An expert said, "Uploading an object is very straight forward. However, an issue is what needs to be ignored" (this refers to the form in the middle that needs to be ignored).
- An expert said, "An issue is that everyone needs to know what tags mean – subjective".
- During the observations, an issue was found getting back to the file upload area.
- An expert said "It could be an issue that you can't allow for the learning object to cover a number of levels".
- During the observations, an issue was highlighted with screen text used - aural or audio?

A number of these comments relating to "issues" were describing usability issues. For example, some were file upload issues, issues with what part of the interface needs to be ignored and the issue of using an Apple Mac. All of these issues can be easily fixed and therefore are not a concern for this research project.

Other issues that are not specifically about usability are:

- An issue found with engaging users and users not being able to tag where necessary.
  - It is felt that these issues could be resolved by educating users about the benefits of the system.
- An issue was found with what the tags actually mean.
  - This would be defined within the specific domain in which the tags exist.
- An issue with the level of the learning objects.
  - It is felt that this would have to be defined within the specific domain that the tags exist.

Problem

The transcript and observation notes raised "problem" in the following contexts:

- A problem was found navigating to the find button to add the searchable object.
- A problem was found with file duplication.
- A problem was found getting back to the Moodle start page.
- An expert said that "global search can be problematic –should be able to be restricted to view material relevant to learner and not all learners.
- A problem with the search form – the design could be confusing for learners as the search box is still showing the results.
- A problem was found remembering how to do the first task.

A number of comments relating to problems were describing usability issues, for example, some were navigation issues and some were file duplication issues. It is felt that all of these problems can be fixed easily and therefore are not a concern.

Useful:

The transcript and observation notes show that the evaluators mention "useful" in the following context:

- "Worried that directing students to things that suit them may not show other material that is really useful to them".
- "Thought it would not be useful if it was a global search – should be subject specific".
- "The concept and the tagging concept is useful".
- "Could be useful for the user to tag things (learning objects and material) themselves (social tagging)".
- "Being able to tailor it to a users specific needs is useful".
- "Useful to be able to view more objects rather than only the ones on their course".
- Expert was "unsure how useful it is due to the fact not used Moodle before".
- "Could be useful to offer learners material appropriate for their learning style".
- "Useful development as focusing on the learning styles".
- "If we could overlay a keyword search then this would become quite useful".

These comments can be grouped generally as cautionary and positive. One example of a cautionary comment is the issue raised that students may be restricted if they are only shown material based on the tags. This issue was actually addressed within the system, as learners are allowed to also search for all learning objects, not just ones based on their learning styles. A further cautionary comment was that it was felt that a global search could be too specific. Again this was addressed due to the fact that learners search specific subjects and topics, rather than all at one time.

Many positive comments were found in the transcript for this. For example, the comment stating that the concept of tagging is useful and the comment about the fact that it is useful to view more objects rather than the ones on their courses. These comments were expected as they reflect back to the answers to the questionnaires about tagging, which were very positive.

7.5 Evaluation results

It is felt that the critical reflection was an important exercise as this has demonstrated that the new enhanced Moodle offers learning object tagging capability for the instructor to author learning material. This learning material can then be provided to the learner based on his or her own requirements and thus creating a personalised learning environment for the learner. This capability is not offered within Moodle at present although Moodle is really only used here as a tool to demonstrate the tagging facility and concept. It demonstrated that a number of research goals were achieved with the extended Moodle, such as the learning object search, adapting to learner's goals, adapting to learner's learning style, learning content specific to their learning need, learning object type specific to their specific learning needs and offers some course structure according to their specific requirements. This led to the enhanced Moodle incorporating tagging, receiving a score of 17 compared to the original Moodle score of 6. It is therefore felt that the enhanced Moodle system will offer the instructor the capability to author learning objects in such a way that it will enable the learner to have the opportunity of a more personalised learning experience.

The tagging search testing demonstrated that appropriate learning objects were provided for the specific type of learner. The two tests for different types of learners provided the expected results.

For the purpose of this research, the tagging methodology and the functionality itself were tested rather than the learning styles and pedagogical factors. Significant research has already been carried out on learning styles and pedagogical factors, so this research has chosen to concentrate on tagging to support authoring of learning content, as there is little or no research within this area. Tagging for the learning styles is used as an example of a discriminatory type and how the tagging concept can work.

The purpose of the expert evaluation was therefore to test the concept of tagging from an instructor perspective. This evaluation raised comments and issues within a number of areas including interface design, tagging content, Moodle, authoring objects, tagging for learning styles and the tagging methodology itself.

Overall the feedback about the interface design was positive. All but one expert found the system easy to use. This was also backed up by the task completion times, which showed that most evaluators had learnt how to use the functionality due to the amount of time taken.

The tagging comments raised were that although the majority of experts stated that they felt tagging the content in Moodle useful, some highlighted that the issue that the tags can be subjective and it may not be clear what the tags actually mean and also who defines the meaning. An example raised of this is the level definition for the learning objects – who defines what the level actually is and is it clear to all users?

Generally the feedback about tagging in Moodle was positive. Although they felt that it is potentially very useful in Moodle, one suggestion was that it could be used as an extension to the current system, rather than a replacement to the current course schedules in place.

As for authoring the objects, the experts gave mainly really positive feedback about this within the questionnaires and during the tests. One negative comment about tagging was that it was felt that it could restrict the learner as they are only shown objects based on their search criteria. The system also allows for the learner to search for all objects and therefore they won't be restricted unless they choose to be. Almost all experts said that they would use a system like it if it was available.

Although not the main focus of the evaluation, the evaluators came up with some interesting comments about tagging for learning styles during the evaluation. The evaluators had a mix of views from the negative factors of restricting the learner from viewing potentially useful information through to the positive comment that learning styles mean learners are thinking about their learning which is always a good thing.

The tagging methodology itself received positive comments from the experts. They could see the benefits of being able to tailor content to a learner's specific learning need, however, one expert said that it could be a good extension to the current traditional course material. Some experts raised comments about the subjective nature of the tag content. The methodology does require the instructor to devise appropriate tags and so therefore there will be an issue with the subjective nature of the tags. This tagging complexity can be handled by a technique such as global schematic mapping. Experts also raised an issue that instructors may find using the methodology for authoring learning objects daunting and raised that there could be an issue with the extra work that is involved.

It was found that during the evaluation that it is difficult to differentiate between the method and the delivery. As it doesn't matter what the delivery mechanism is and as long as the tagging search is implemented then the delivery mechanism will look the same and what the user will see will be the same (the Moodle and C# implementations demonstrate this) therefore it was found that comments of the experts on the outcome of the methodology are not dependent on the delivery mechanism.

The frequency analysis threw up some interesting text that required further investigation and analysis.

Interestingly, the comments made about tagging when put in context were more negative compared to the questionnaire results that were generally very positive. These negative comments were mainly coming from concerns about how the instructor would use the tagging, whether they could use it and whether it would add too much to their workload and not about the tagging concept itself.

Additionally, the subjective nature of the tags (e.g. the level tag) was raised as an issue.

It was found that most of the issues and problems with the system highlighted by the instructors were to do with the interface design, which it is felt can be easily fixed and therefore were not of significant concern for this research project. It was also found that most of the instructors found the system intuitive to use, as they were able to enter in appropriate tags as necessary.

Comments about the usefulness of the system were grouped into two main areas, cautionary and positive. The cautionary comment was due to the issue that students may be restricted if they are only shown material based on the tags and that on the other hand a comment was made that a global search could be too specific. Positive comments included that some experts found the concept of tagging useful and particularly useful to be able to search for other learning objects and not just the objects provided by the instructor on a course.

7.6 Conclusion

Therefore, to conclude it is felt that from the critical reflection the research demonstrates that the enhanced Moodle is an appropriate tool to demonstrate the discriminatory tagging design. The author argues that it has demonstrated that the version of Moodle incorporating the tagging offers the possibility of enhanced personalisation and adaptability for the learner.

The evaluation has also shown that the tagging search testing undertaken has demonstrated that the tagging system can provide different learning material for learners with different learning requirements. Therefore, the evaluation has demonstrated that the tagging provides support for a discriminatory approach to the provision of learning content, and the tag set used can be defined according to the discriminatory type adopted.

The expert and cognitive analysis has demonstrated that the instructors are able to get through the tasks in relatively good time and that completing the tasks doesn't require any specialist support on the part of the instructor. The feedback from the expert analysis indicates that instructors want a system that is intuitive, easy to use and does not require any specific technical knowledge to use it. If the system is easy to use and not requiring any technical knowledge then this will allow for the instructor to concentrate on where their expertise lies rather than having to become an expert in the technology. Due to some of the comments from the instructors (workload concerns specifically), the evidence suggests that if the technology is too complex and requires the instructor to learn new technologies then they will not use it.

As far as the tagging methodology is concerned, the research has demonstrated that instructors are positive about the use of tagging content and do see the potential of its use within e-learning. However, although they see the potential, work has shown that instructors are unsure how this methodology could work due to the fact they feel it would prove to be too much extra work. This is going back to the issue about the workload for an instructor that the author found during the expert analysis.

The author asserts that the tagging developed within the methodology can be hosted within any e-learning platform. Moodle was used as an example e-learning platform and with this in mind the author found that the instructors saw the benefit of using this tagging methodology as an extension to the normal facilities available in Moodle. The author also found that the instructors thought that tagging learning and assessment content within Moodle was useful. It was also found that as the implementation of the methodology within platforms would look the same to the user, the comments from the experts about the outcome of the methodology are not dependent on the delivery mechanism.

One interesting outcome found during the expert evaluation is that instructors feel that authoring learning material to provide personalisation for different learners has potential but they have little knowledge of it. This is very interesting as personalisation for different learners within e-learning system has been a large research area for many years. The author therefore found that it was interesting to see that this research had little or no impact with the academics doing the expert evaluation. Furthermore, these instructors have an interest within this area and they are already engaged in the use of learning technologies and yet being able to individualise learning within a cohort based situation has not impacted on them. The author asserts that the reason for this is that currently only complex technology is available to do this and this is not in wide spread use, issues with this are that the instructor would not have time to learn the technology. This therefore relates back to the earlier finding of the instructors wanting a tool that is easy to use and therefore this will enable a tool to be more widely used. These technologies are also not in the main stream at present so they may not even be aware of them. The author therefore feels that using this tagging methodology could provide a more widely used tool to personalise learning objects for different learners.

The author found that the instructor's views on learning styles reflected the research and were both critical and positive. The research showed that some experts asserted that it was useful for learners to view material based on their learning style and others asserted that doing this could restrict the student from viewing potentially useful information.

As far as the learning styles are concerned, the tags created within the methodology are not confined to learning styles or accessibility and the tags could incorporate any discriminatory type proposed (e.g. discriminatory tagging for cultural appropriateness). Learning styles were used within this discrimination example, as there is a widely accepted belief that we do have certain characteristics that impact on the way that we learn given no other confounding factors. The research has shown that the tagging methodology can be used to create discriminatory tags allowing the instructor to create a constrained set of materials targeted towards an individual, which can then be personalised further through user modelling. The author stresses, however, that the discriminatory type devised should be the most relevant for the needs of the domain. However, due to the inherent subjective nature of the tags there will always be some kind of limitation or acceptance about the tags to confirm that it will be the best tag set for a particular situation.

During the cognitive analysis, the evaluation found that the instructors suggested a number of requirements that are not currently in the system which are that it could be used by students as an aid for feedback with searchable learning object tags, that it could be useful for the learner to tag learning objects themselves (similar to social tagging systems) and also that keyword searches would be useful to enhance the current search functionality.

The research undertaken found that the cognitive analysis highlighted some interface improvements that would improve the system, which are that a learning object level could span a number of levels (both final year and masters for example) and once an instructor has selected whether it is a learning or an assessment object, the learning resource type will change to reflect this choice. The level of a learning object would need to be defined and whether a learning object could be for a number of learning levels. The author feels that this would depend on the domain.

This discriminatory methodology uses learning styles and accessibility as an example of discrimination however it could be used for other types of discrimination. The evaluation has shown that this research has created a test bed for discriminatory tagging examples, which enables the instructors to easily test out discriminatory tagging, which is not possible to do at present within a learning environment or learning resource repository.

8 Conclusion and further work

8.1 Introduction

This research project covers the area of personalised and adaptable learning and in particular within an e-learning context. This project evolved to cover many research areas including personalised learning, e-learning environments, authoring tools, tagging, learning objects, learning theories and learning styles.

Initially the main focus for the research project was to provide a personalised and adaptable learning environment for students based on their learning style. This then led to a specific interest about how an academic can create, tag and author learning objects to provide the capability of personalised adaptable e-learning for a learner. This chapter describes the research undertaken, the findings and how this influenced the progression of the project.

As set out in the introduction, the initial research hypothesis was as follows:

"A mechanism can be developed to personalise learning materials to an individual learner according to their learning style".

This hypothesis was reviewed and revised during the research project and this is described within this chapter.

Set out in the introduction, the main aims of this research project were as follows:

- To understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles.

- To develop a unique approach that supports the personalisation of learning materials and the use of learning styles.

Also set out in the introduction, the main objectives of this research project were identified as follows:

- To carry out a critical and comprehensive review of research within the area of e-learning tools, personalised and adaptive learning, and learning styles.
- To investigate current trends and technologies within e-learning.
- To create and evaluate a model to offer personalised learning based on a learner's learning style.

Further main objectives that were highlighted during the research project were identified as follows:

- To investigate adaptive systems incorporating learning styles.
- To carry out an evaluation of learning styles for adaptability and personalisation.
- To carry out an evaluation of the personalisation and adaptability offered by popular e-learning platforms.

This chapter describes the work undertaken within each chapter of the thesis and how the aims and objectives were satisfied during the duration of this project.

8.2 Research conclusion

This section of the research conclusion chapter will describe the work discussed within the main chapters of this thesis and then highlight the aims, objectives and hypothesis to see what is satisfied or changed based on the findings of the research. Therefore the research findings and how these influenced the direction of the research work undertaken within this project will now be described.

The research undertaken within Chapter 2 has partly satisfied the aim of "to understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles". This is due to the fact that the research evaluates learning theories, approaches and styles.

The learning theories and approaches research described in Chapter 2 demonstrates that the constructivist learning theory fits in with personalised and adaptive learning. The research also demonstrated that the heutagogical approach is a good "fit" within e-learning environment as it allows learners to take charge of their own learning and therefore supports greater flexibility in learning.

The learning style research described in Chapter 2 demonstrates a critical and comprehensive review of learning styles. Despite the criticisms highlighted within the chapter from some researchers about learning styles (described in detail by Coffield et al. (2004)), the author decided that for the purpose of this research, incorporating learning styles into a methodology within a personalised learning environment would be very useful. The main reasons for this, the author argues, are that at present there is no alternative to learning styles and also that the number of learning style models available demonstrates that there is a widely accepted belief that learners have certain characteristics that can impact on the way that they learn and learning styles can reflect this.

A further project objective was highlighted during the research as, "to carry out an evaluation for learning styles for adaptability and personalisation" and the evaluation of learning styles was described within Chapter 2. This evaluation took place in order to evaluate the learning styles for their suitability for use within a personalised learning mechanism. The evaluation described within this chapter was based on the criteria proposed by Sampson and Karagiannidis (2004). Fleming's VARK was found to be the most suitable learning style to incorporate within a personalisation model and the main reasons for this were that the measuring tool offers a concise questionnaire for a learner to complete and that the learning style categories map clearly to learning object file types. This learning object mapping is in contrast to other learning styles in which the mapping can be complex, for example the Dunn and Dunn learning style model.

This research therefore satisfies part of the project objective "to carry out a critical and comprehensive review of research within the area of e-learning tools, personalised and adaptive learning, and learning styles". Furthermore, the research described the selection of the learning style to be used for the mechanism, as defined in the hypothesis "A mechanism can be developed to personalise learning materials to an individual learner according to their learning style".

Finally, the research within Chapter 2 led to a further project objective being identified, which was to investigate adaptive systems incorporating learning styles. This review was felt important for the project due to the fact that learning styles are to be used for the personalisation and adaptability within the methodology. The next area of research described in Chapter 3 is within the area of e-learning, including e-learning platforms, personalised and adaptive learning, adaptive systems.

The research described in Chapter 3 completes the first project aim of "to understand the body of knowledge relative to personalised and adaptive learning techniques, e-learning tools and learning styles" as the work within the chapter discusses personalised and adaptive learning techniques and e-learning tools. The findings described in Chapter 3 for authoring tools, adaptive hypermedia systems and e-learning platforms are as follows:

- General authoring tools are not flexible enough for current learners as they are limiting and do not offer suitable functionality.
- Adaptive hypermedia systems have been developed, though issues were found with these including flexibility, re-use and system integration problems due to the nature of the architecture.
- E-learning platforms do not offer much in the way of personalised learning for a learner. They have a number of tools available for the instructor and learners. However, these tools are generic and do not reflect a personalised learning environment.

The work within this chapter also completes the first objective of "to carry out a critical and comprehensive review of research within the area of e-learning tools, personalised and adaptive learning, and learning styles" as e-learning tools, personalised and adaptive learning are critically reviewed.

Furthermore, the second objective of "to investigate current trends and technologies within e-learning" is also satisfied within Chapter 3. The current trends in technologies within e-learning led to an investigation into tagging. This investigation showed that tagging is not currently in widespread use within e-learning. It was found, however, that it could be a useful tool for offering personalised and adaptable learning to the learner.

The further objective, defined in Chapter 2, which was to carry out a review of adaptive systems incorporating learning styles, is also described within Chapter 3. The findings of this review were that with adaptive systems that incorporate learning styles, Brusilovsky and Milan (2007) state that there is no proven recipe for the application of learning styles and that they are also unclear what is worth modelling. The research shows that generally these systems are too complex to be widely used by non-specialist academic staff.

The further objective of "to carry out an evaluation of the personalisation and adaptability offered by popular e-learning platforms" and this objective was satisfied within Chapter 3. The main findings for this objective are that e-learning platforms do not offer a true personalised learning experience for a learner.

Due to the research findings relating to tagging and adaptive systems described within Chapter 3, the author proposed that this research demonstrated that the hypothesis "a mechanism can be developed to personalised learning materials to an individual learner according to their learning style" would be improved if the proposed mechanism were a tagging methodology that will provide personalisation within the context of a hypermedia system. The work also demonstrated that this mechanism should also adhere to standards where possible to offer personalised learning addressing issues found with other adaptive systems incorporating learning styles described within this chapter.

The outcome of the background research suggested that one potential solution to the issue of personalising content according to learning styles could be the development of a tagging system to provide personalised and adaptable learning utilising concepts from adaptive hypermedia systems. Following on from this the author therefore decided to create a methodology to try to address some of the issues found within the research, including the problems of system flexibility, system integration and reuse.

With this in mind, the background research findings led to the hypothesis being revised to, “a tagging methodology can be developed to personalise learning materials to an individual learner according to their learning style”.

Chapter 4 describes the work to satisfy the research aim of “to develop a unique approach that supports the personalisation of learning materials and the use of learning styles”. This tagging methodology was developed to incorporate learning objects being tagged according to their subject and topic, learning style, level, object file type and object resource type. This work has shown that this tagging methodology provides two significant benefits:

- It allows for instructors to have the capability of authoring learning objects and making sure that the multiple representation of the learning object are consistent. Current common e-learning environments do not offer this as the learning objects may frequently only be represented once.
- The learners can potentially personalise their own learning space based on their individual requirements. The research demonstrates that this is also not available in current e-learning environments.

The design of the tagging part of the methodology described within Chapter 4 also completes the first part of the objective of “to create and evaluate a model to offer personalised learning based on a learner’s learning style” as set out in the introduction of this thesis.

The final section of chapter 4 describes the methodology steps in detail using another discriminatory example of accessibility. This demonstrates that this methodology can be used for multiple discrimination models and learning objects can be tagged within multiple tags for different discriminations and not just for learning styles. Therefore at the end of Chapter 4 the hypothesis was revised to, “a discriminatory tagging methodology can be developed to provide personalised learning materials to an individual learner”.

Chapter 5 describes the implementation work to satisfy the research aim of “to develop a unique approach that supports the personalisation of learning materials and the use of learning styles". This chapter also describes the implementation of the methodology which will be able to facilitate the evaluation part of the objective "to create and evaluate a model to offer personalised learning based on a learner's learning style" as set out in the introduction of this thesis. Chapter 5 describes how this model was implemented within Moodle to demonstrate that it could provide appropriate learning content to a user based on their learning style. The implementation makes use of Moodle modules and plug-ins and both the instructor and learner side of the system have been developed.

Some advantages of using Moodle were highlighted during the implementation stage and they are described in Chapter 5. However, Moodle is used for evaluation purposes only as the author argues that the implementation part of the methodology could be incorporated into any e-learning system or platform. Chapter 5 also describes the common steps that need to take place in order to implement the tagging discrimination into any learning environment or system.

The experimental design described within Chapter 6 is designed to test the mechanism defined within the hypothesis. The experimental design described was undertaken for the evaluation part of the objective "to create and evaluate a model to offer personalised learning based on a learner's learning style".

During the experimental design phase described within Chapter 6, it was decided to concentrate on evaluating the authoring side of the system rather than the learner side. It was found that other research projects have evaluated the personalisation of learning content based on a learner's learning style (see Graf and Kinshuk (2007), discussed in Chapter 3). Consequently, the author felt that there was a sufficient body of existing evidence in this area whereas there was limited research available on the authoring side. Therefore focusing on the instructor side led to the hypothesis being revised again to, "a discriminatory tagging methodology for authoring content can be developed to personalise learning materials to an individual learner".

The experimental design defines how the implementation part of the methodology is evaluated. The first evaluation defined within the experimental design was the critical reflection based on an extension of the criteria proposed by Rego et al. (2007) and this evaluation demonstrated that the new enhanced Moodle offers learning object tagging and capability for the instructor to author learning material. The critical reflection undertaken in Chapter 7 demonstrates that a learning object tagging functionality was not available in the original Moodle. The author therefore asserts that the critical reflection demonstrates the enhanced Moodle system will offer the instructor the capability to author learning objects in such a way that will enable the learner to have a more personalised learning environment.

Experts undertook further evaluation and the experts were academic instructors from different disciplines having an interest within e-learning. The outcome of the evaluation undertaken by the experts demonstrates the following:

- The instructors in the study want a system that is intuitive, easy to use and does not require any specific knowledge to use it. The evidence from the evaluation demonstrated that this would enable the instructors to concentrate on where their expertise lies rather than becoming an expert in the technology.
- The instructors in the study are positive about the use of tagging and see the potential for using it within e-learning.
- The instructors in the study have little knowledge about personalisation of learning. Therefore any research undertaken within this area has had little or no impact so far with the academics.
- Personalised and adaptable learning has not impacted on mainstream e-learning due to the complex technology that is often required to provide it. This technology requires additional skills that most academics do not have and therefore they may be resistant to learning the technology.
- The tagging methodology provides a tool that allows for a more widely used mechanism to be personalised for different learners.

The main criticism of the methodology coming from the experts came from the use of learning styles within the methodology. The research focus, however, is not on learning styles as the criticisms of these have been highlighted within the background research and therefore the author was aware of this.

The author therefore argues that learning styles were used within this methodology as an example of how a system could be personalised because there is a widely accepted belief that we do have certain characteristics that impact on the way that we learn given no other confounding factors and that learning styles can reflect this. The research demonstrated therefore that learning styles are used as examples of a discriminatory type but the tags devised do not need to be restricted to one type and can be flexible and can incorporate any discriminatory example as required.

The evaluation has shown that the enhanced Moodle system offers the instructor the capability to author learning objects and this will enable the learner to have a more personalised learning environment. This would be the same for other e-learning platforms or systems should they incorporate the discrimination tagging.

Therefore the outcome of the evaluation, therefore, is that the tagging methodology has become one that is flexible to the needs of the required discriminatory type. The work demonstrates that tags can be added for any discriminatory type required and that the tags will be devised and managed according to the specific domain requirements. The implementation part of the methodology also will be able to be implemented within any e-learning authoring environment. Moodle was used for demonstration purposes but the implementation could be on any other platform or system as required.

The tagging methodology is both flexible and easy to use. The xsd can be provided to a community of instructors with will enable standardising of tagging in the same way as the metadata models are currently provided. Instructors can create their own xsd or reuse an existing one so therefore this creates the flexibility. Issues with the semantic meanings of tags are highlighted within this research and it is proposed that using a technique such as global schematic mapping would be useful to solve the semantic issues. This discrimination tagging, however, allows much greater freedom to instructor's who don't wish to be bound to a standard metadata model, and wish to extend their tag sets.

Furthermore, the discriminatory tagging demonstrated within this research differs from the other learning resource repositories available (e.g. Jorum) as these systems use metadata and not tagging to enable the search. Additionally, mainly keyword searches are used within these systems and they don't provide a tag set for a discriminatory type. Although different search criteria are available within these systems, they lack the granularity that is offered by the tagging described within this research. The discriminatory tagging methodology described within this thesis therefore provides a more flexible, reusable and personalisable capability than standard metadata models supported within other learning resource repositories due to the fact that there can be a number of discriminatory models associated with a learning object.

The research has demonstrated different discriminatory types of learning styles and accessibility; however, it could be used for any number of discriminatory types (for example culture, religion or social). The author argues, therefore, that this research has created a test bed for discriminatory tagging, which enables the instructors to easily test out different types discrimination. The research has shown that testing out different discriminatory types is not possible to do with the current systems available including systems incorporating metadata models.

8.3 Main contributions

The main contribution of this thesis is a platform independent general-purpose discriminatory tagging methodology. This methodology allows for any type discrimination between learners to be used and the example demonstrated within this thesis includes discriminating according to a learner's learning style and accessibility. This type of platform independent flexible discrimination tagging does not exist within current e-learning platforms.

Additionally, a contribution is the creation of an authoring tool to create a test bed for other types of discriminatory tagging (within Moodle) that is simple to use and does not require any technical knowledge to use. This tagging system allows an academic to tag learning objects according to the discriminatory type to facilitate learning object personalisation and reuse.

A further contribution is a review of authoring tools and e-learning platforms. This review demonstrated the lack of the personalisation and adaptability that they offer for the learner within e-learning systems. Additionally a review of adaptive systems, which adapt to a learner according to their learning style, is also contributed. This review describes how the systems adapt and the limitations of the systems.

8.4 Future work

This research project could be taken forward in a number of ways and this section will describe some of these.

1. This methodology could be used to incorporate any discriminatory tagging approach relevant to a specific domain. Learning styles and accessibility were just used as an example. Different disciplines may have tags relevant to their own specific domain that they would like the instructors to use. It is felt that devising other types of discrimination and testing these within these different disciplines within different learning systems would be an interesting way to take this research forward.

2. Testing multiple xsd's incorporating some semantic issues would be an interesting way to take this research forward. In particular, testing out a technique such as global schematic mapping in order to handle the complexity and to create an ontology of terms.

3. A further way to take this research forward would be to undertake enhanced development of the personalised learning package for the learner either with the use of other learning style models or using another discrimination type. This development could enable the learner to manage their own

learning material and construct their own personalised learning space. It is felt that there is a lot of potential for improving this functionality for the learner.

4. Description and keyword tags are not used as part of the tag search criteria at present due to possible issues with the semantic meaning and lack of consistency of these words. Once these issues are resolved, perhaps by the domain agreeing on common tags to use, this could provide for an additional enhancement to the search functionality.

5. As mentioned by one evaluator, one further enhancement could be that learners could tag the learning objects themselves. This will become similar to the social networking tagging environments. Although issues with the semantic meaning of tags would need to be resolved, the learner could add tags according to their usefulness and relevance of the learning objects for example.

6. One further development could be that the tag search could be used to facilitate a recommendation search. For example, if a learner selected a particular learning object previously, they could be presented with other learning objects that were deemed to be relevant or related to the learner's previous search.

8.5 Final statement

The key achievement of this thesis is as follows. Personalised and adaptive e-learning software is not commonly used due to a variety reasons including ease of use, flexibility, reuse, availability of personalised systems and system integration problems. This research project has created a discriminatory tagging methodology that can easily be used by instructors to enable personalised learning for a learner. This methodology is flexible as it is not tied inherently to a specific discrimination, nor tied to a specific e-learning system.

Prior to this methodology being available, it was extremely difficult to test out discriminatory types and within this research a test bed has been created which can easily test a discriminatory type.

Appendix A

A.1 Task sheet for structured walkthrough study

Detailed structured walk-through Study

This system is an extension to Moodle for authoring and searching learning resources. The researcher will record any questions and comments that you have about the system.

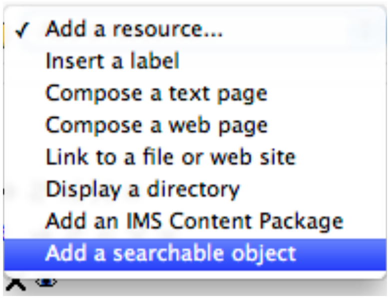
Task 1:

Role of the instructor: adding a searchable learning resource to the system

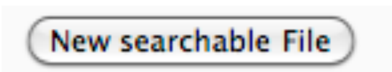
1. At the ***programming / asp.net programming*** course page

   Find the ***Basic web topic*** and select the drop down showing list ***Add a resource…***

2. Select ***Add a searchable object***
(Note that this is at the bottom of the list and you may need to scroll down to see it)



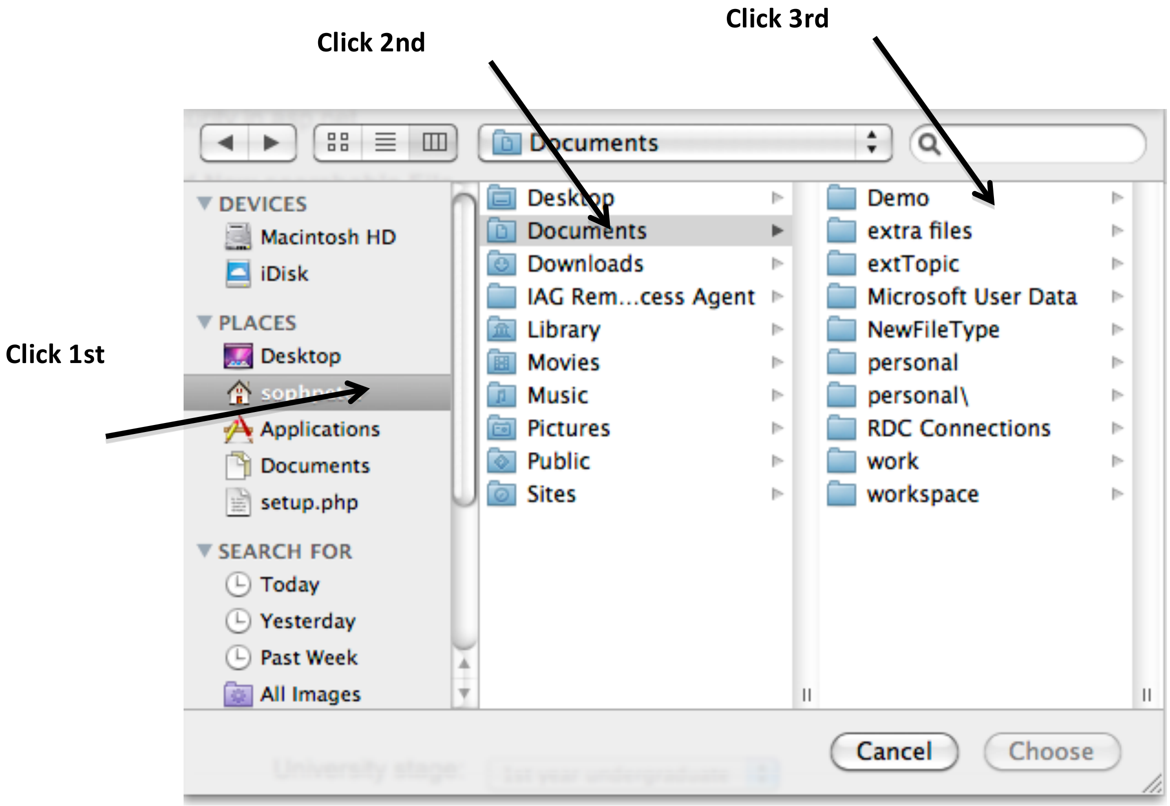
3. Scroll down to the ***Add a searchable object*** section and select the ***New Searchable File*** button to add details about the learning material (note: alternatively the resource could be a searchable URL)



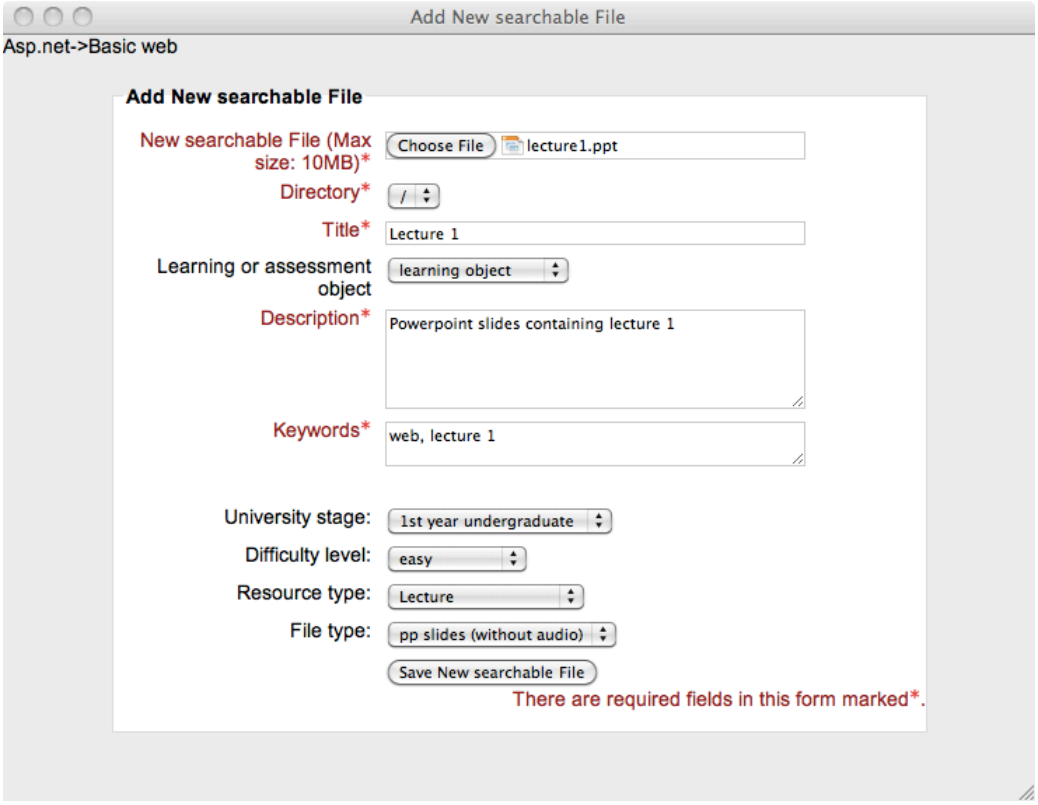
4. Note that a new window will pop up

5. Fill in the ***Add new searchable file*** form as follows:

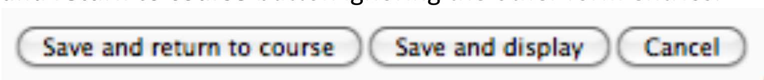
   - Browse for a file, select and choose the powerpoint slide file called **lectureTest.ppt** in the folder **Documents/Demo/Test/** (see the following screen shot for further clarification)



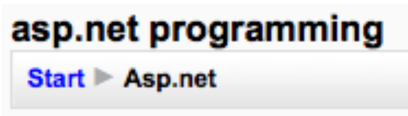
- Once the file is selected, add a title **Lecture 1**
- Select ***learning object***
- Add a description **Powerpoint slides containing lecture 1**
- Add keywords **web, lecture 1**
- Select ***1st year undergraduate***
- Select ***easy***
- Select ***lecture***
- Select ***PP slides (without audio)***
- Click the ***Save New Searchable file*** button to return to the adding a new resource page



6. Scroll down to the bottom of the adding a resource window and click the ***Save and return to course*** button ignoring the other form entries.



7. Click the **Start** hyperlink at the top left to return to the home page



Task 2:

Role of the learner: searching learning resources based on individual criteria

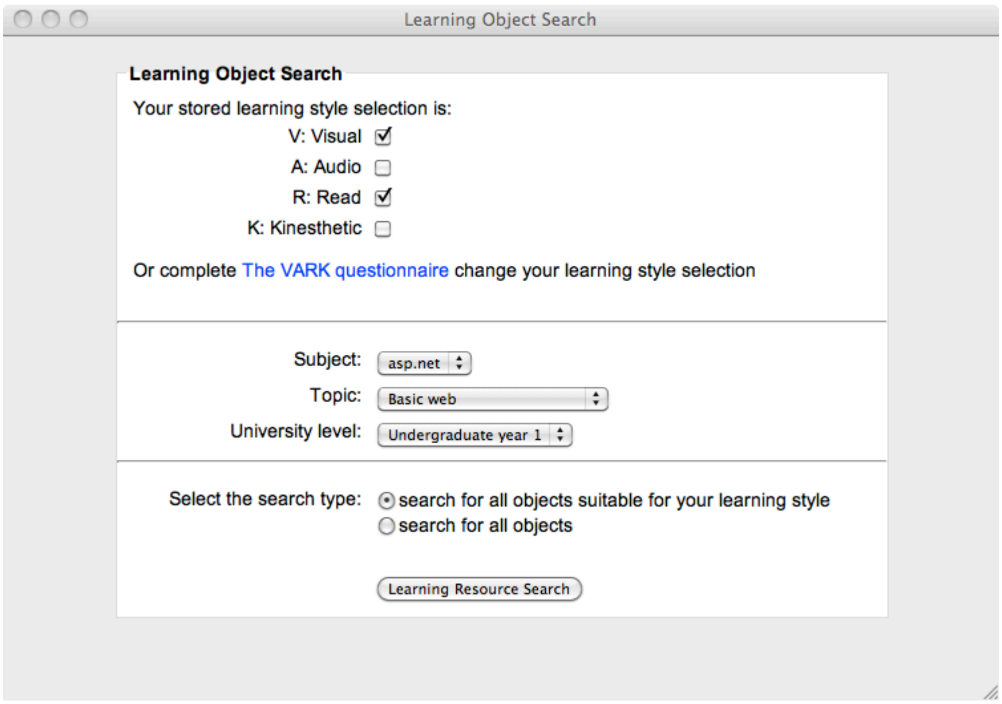
1. Find the block ***The Learning Resource Repository*** on the right hand side of the screen and click the ***Search*** button

2. In the learning object search window select the learning style as *VR* (select check boxes for both V: Visual and R: Read).

3. Select ***asp.net*** subject and topic as ***Basic web*** and University level as ***Undergraduate year 1***

4. Select the default option search all objects suitable for your learning style

5. Click the ***Learning Resource Repository Search*** button

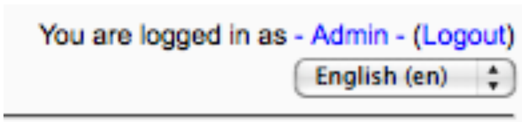


6. Scroll down and view the objects that are suitable for the learning style: note that you have been provided with learning material suitable for Visual and Read learning styles – PP slides (without audio), vodcast and text files for example.

7. Make some file selections (check the select object check boxes) and scroll down and click the ***save object selection*** button

8. Select ***close and return to main page***

9. ***Logout*** from the main page



A.2 Task sheet for cognitive analysis study

Cognitive walk through Studies

These tasks should be completed whilst using the thinking aloud method. The researcher will describe this method to you together with an overview of the cognitive walk through tasks.

Task 1: Authoring material

The following ***Programming, asp.net, basic web***, ***1st year undergraduate*** learning materials are available in the **Documents/Demo/New Basic Web** folder available to author and upload within Moodle:

File name	Title	Learning or Assessment object	Description	Keywords	Difficulty	Resource type	File type
WebLecture1.ppt	Lecture 1	Learning	Lecture 1 basic web	Basic, web	Very easy	Lecture	PP slides (with audio)
WebMultimedia1.html	Multimedia File 1	Learning	Multimedia 1 basic web	Multimedia, basic, web	Medium	Simulation	Multimedia
WebPodcast1.html	Podcast 1	Learning	Podcast 1 basic web	Podcast, basic web	Medium	Lecture	Podcast
WebExercise1.doc	Exercise 1	Learning	Exercise 1 basic web	Exercise, basic web	Difficult	Exercise	Text

1. Using the choice of learning material available in the **Documents/Demo/New Basic Web** folder, author and add a shareable learning object suitable for a learner who prefers kinesthetic learning.

   Upload the object, add the description of the learning resource and add the corresponding tags for the material.

2. Using the choice of learning material available in the **Documents/Demo/New Basic Web** folder, author and add a sharable learning object suitable for a learner who prefers Read/Write learning.

   Upload the object, add the description of the learning resource and add the corresponding tags for the material.

Task 2: Searching for learning material

1. You are an **Undergraduate Year 1** learner with the learning style category ***VISUAL (V)***. You would like to search for some ***asp.net, introduction to web forms*** learning resources suitable for your learning style preference. View and select a variety of suitable learning resources.

2. You are an **Undergraduate Year 2** learner with the learning style category ***Aural and Kinesthetic (AK)***. You would like to search for some ***asp.net, introduction to web forms*** learning resources suitable for your learning style preference. View and select a variety of suitable learning resources.

Appendix B

B.1 Related publications published during the duration of this thesis

Peter, S., Mackinnon, L., Bacon, E. and Dastbaz, M. (2011). “Tagging learning objects in Moodle for personalisation and re-use”. In T. Bastiaens and M. Ebner (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2011 (pp. 2259-2266). Chesapeake, VA: AACE.

Peter, Sophie E., Bacon, Elizabeth and Dastbaz, Mohammad (2010) “Adaptable, personalised e-learning incorporating learning styles”. Campus-Wide Information Systems, 27 (2). pp. 91-100.

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