An Enhanced Semantic VLE Based on schema.org and Social Media

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Abstract

After the arrival of the web in the 1990s, educational institutions started to maintain their learning materials within Virtual Learning Environments (VLEs), as the web is a significant source of material for many students and teachers. However, there has been less development in the current VLEs in the past few years, which remain heavily centred on single institutions even though the web has been developing (e.g., web 2.0, web 3.0). There is a clear need to integrate VLEs with the wider and social Web and maintain its learning contents freely open in order to support the sharing and reuse of learning resources.

In this PhD project, we have prototyped a simple VLE that makes use of Version 7 of the Semantic Content Management System (SCMS) Drupal in order to provide a more open, social and semantically structured learning environment. Essentially, we aim to add semantic markup based on Schema.org vocabularies (the semantic markup that is supported by major search providers including Bing, Google, Yahoo! and Yandex), and integrate social networking and media to develop and enhance VLEs by improving sharing, discovering and reusing of learning contents.

In June 2011, the major search engines (Bing, Google, Yahoo! and Yandex) announced the new innovation of Schema.org. This PhD project focuses also on our proposal to Schema.org by proposing additional concepts to describe VLEs’ content with rich semantic information due the limited support for describing educational resources in the current schema. This proposal aims to extend to the previous work that has been included in the schema by The Learning Resource Metadata Initiative (LRMI) in order to provide an enhanced approach to describe learning contents with rich semantic data in a VLE context.

Through this thesis project, we will introduce, describe, evaluate and discuss the prototyped VLE in order to demonstrate the advantages of social and semantic web technologies for VLEs. We demonstrate how an advanced SCMS such as Drupal can offer advantages over existing VLE platforms in terms of: sharing of learning content with social networks; provision of advanced media features. We also demonstrate how Drupal’s support for schema.org can be used to enhance the findability of on-line learning content, and propose enhancements to schema.org that will make it more relevant to the needs of learning platforms. This proposal has been evaluated by schema.org and LRMI and a working group set up to take the proposal forward.
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1 Introduction

With the fast growth of the Internet, connectivity, accessibility, and reusability of content have become inspirational to the use of the World Wide Web for educational systems. Virtual Learning Environments (VLEs), or e-Learning systems, are fast becoming an integral part of the learning and teaching process (Vanraaij & Schepers, 2008). Nowadays, most educational institutions and universities are either using off-the-shelf virtual learning environments (e.g., Moodle, Blackboard, webCT or Desire2Learn) or, much less commonly, they use their own in-house environment. However, with the steady commoditization of VLEs, there has been less innovation in these systems in the past few years even though the web has been developing through web 2.0 (e.g., social networking and media) and web 3.0 (e.g., linked data and semantic web technologies).

Over the last fifteen years or more, we have increasingly seen advanced technologies such as the semantic web or web of data used to facilitate reusing and sharing of data on the web (Berners-Lee, Fischetti, & Michael, 2000) (Bizer, Heath, & Berners-Lee, 2009). Semantic web technologies have passed through different stages of development since their appearance. An example of this is the semantic markup of web content by using a special format (RDFa, Microdata and Microformat) to markup the web content by embedding rich semantic descriptions within the HTML code.

More recently, there has been a focus on creating and supporting “a common set of schemas for structured data markup on web pages” (Schema.org, 2014a) with the launch of the Schema.org initiative in June 2011. This is a joint effort between the major search engines, Bing, Google, Yahoo! and Yandex, to have global and official vocabularies that can be understood by the big search engines.

To our knowledge, all the “conventional” virtual learning environments lack enhanced semantic features and support. Consequently, a Semantic Content Management System (SCMS) was selected in this research to deploy and support the development of different parts of e-Learning services for higher education institutes. Our internal review was aligned with the findings more recently published in (Bratsas et al, 2012) that Drupal (a Semantic CMS) currently provides a more usable platform for the development into a Semantic Learning Management System (SLMS) than does Moodle.
In addition, we believe that we can increase the attractiveness and sharing of content of these learning systems by linking to social networks and media to facilitate a freely open environment unlike “conventional” virtual learning environments. Nowadays, students need a high level of social and creative engagement in order to learn in highly interactive learning platforms, which allow for communication and collaboration (Craig, 2007). As we will see through this thesis project, integrating these learning environments with the wider and social Web will facilitate and enhance the development of a range of new services for VLEs. The remainder of this chapter will define and give a short introduction to the important terms in this PhD project. This chapter ends with our research hypothesis and the structure of this thesis project.

1.1 Introduction to Virtual Learning

Over the past decade or so, the web has dramatically changed the way of education, through its provision of a significant source of learning materials in additional to traditional classroom lectures and textbooks. Furthermore, most universities around the world have been using the web recently due to the benefits to learning of fast and extensive access to learning material. It offers an extremely large source of education materials available for students and teachers. For instance, students can access their courses’ contents (lectures notes, supporting materials, etc.) online anytime. Furthermore, it can establish open communication between teachers and students after and before the class; which is called a virtual classroom or digital collaboration. These benefits are summarised succinctly in the Wikipedia definition that a VLE: “models conventional in-person education by providing equivalent virtual access to classes, class content, tests, homework, grades, assessments, and other external resources such as academic or museum website links. It is also a social space where students and teacher can interact through threaded discussions or chat.” (Wikipedia, 2015).

Recently, many students have turned to web learning to access their resources online. The term that describes the use of web with learning is called e-Learning. It means the use of advance technology of the “Internet” to support both synchronous and asynchronous access to learning content (Uden et al. 2007). Currently, the term virtual learning environment has appeared to be the interface for e-Learning systems that are on the web (Abdul-Kader, 2008). Following the prediction of (Vanraaij & Schepers,
Virtual Learning Environments (VLE) or e-Learning systems have become an integral part of the learning and teaching process.

1.1.1 What is a VLE?

There are many attempts to define the meaning of VLE. We will provide two definitions because there are some different views of VLE. The first one is a broad definition of VLE. According to Anup, Ragade, & Wong, a Virtual Learning Environment is:

“An integrated university environment where students can apply for admission over the internet, enrol in the classes offered by VLE after admission, access a complete course, take tests, and interact with the professors as well as classmates.”

(Anup, Ragade, & Wong, 1998)

This definition seems quite broad because it talks about the online admission when online admission for educational institutions is rare at the present. Therefore, we should define VLE with the current aspects of the current learning environments in mind. An early comprehensive definition of a VLE was provided by Piccoli, Ahmad, & Ives; a VLE is a computer-based environment that is an open system (in that it allows interactions with other participants), providing access to a wide range of resource materials (2001). A VLE is a web-based platform that provides students access to learning materials or tools (e.g. course contents, learning resource and discussion board) without limitation of place and time (Vanraaij & Schepers, 2008). It provides for students to access their course materials online, view lectures, tests and interact with other students and the lecturer in the course. They can retrieve their course materials and interact with others at any time convenient for the participants. VLEs are connected to the Internet. Therefore any user who would like to connect to a particular VLE will need an Internet browser that supports HTML to connect to the system and use it. Recently, with current innovation of smart phones, some VLEs have started to create new Apps for their systems in order to facilitate using these VLEs via mobile smart phones.

In addition, the main aim of a VLE is to make education available to very large numbers of people (Piccoli et al., 2001). VLEs provide several advantages in terms of flexibility and convenience comparing with the traditional learning environments. According to Anup, Ragade, & Wong, the overall objectives of the virtual learning environment are: (1998)
• Creating a learning environment for students.
• Offering geographically broad access to large scale courses that are in the learning system.
• Providing a flexible and dynamic learning environment for students online.
• Providing a course repository.
• Developing the current learning environments.

1.1.2 Growth in use of VLEs

In this section, we will present a quick overview of the milestones of learning platforms from the past till the present. An extensive presentation on learning systems milestones can be found in (Moodle, 2011).

In 1960, the PLATO (Programmed Logic for Automatic Teaching Operations) system was created by University of Illinois at Urbana (Bitzer et al, 1961). This system was operating until the 1990s. In 1982, The Computer Assisted Learning Centre (CALC) was established in Rindge, New Hampshire. It provides offline computer-based adult learning. The learners can have individual lectures by using a computer. In 1987, Jones launched in Mind Extension University a cable channel that broadcasts educational programs.

After the web came in the 1990s, the learning systems started to link their systems to the Internet and they called them virtual learning environments or e-Learning systems. In 1994/95, CALCampus website was the first system to implement the concept of a web-based school that provides the materials online. After that, several learning systems have been published. For example, the famous two VLEs, WebCT 1.0 and Blackboard that were created in 1997. Another example is the Desire2Learn VLE, which was funded in 1999 (Desire2Learn, 2011). In 2001, Moodle.com launched their VLE and they called it Moodle. After that, some of these learning systems republished their systems with a new version such as Moodle, who announced in 2006 for the new release of their software. Furthermore, these learning platforms are used widely now within universities. More information about these systems will be discussed in details in the next chapter. The use of these systems within universities will be discussed in the following subsection.
1.1.3 Current usage within universities

Recently, most universities around the world have been using one or more of the virtual learning environments. They use these VLEs to facilitate the access of learning materials for their students. The lecturer can produce the content of any course online and students can then access these materials online. The most common VLEs and learning management systems (LMSs) that are used now by many universities are: Moodle, Blackboard, Desire2Learn and WebCT. However, some universities have changed the learning system that they use due to the limitations of the current system. For example, Surrey University used ULearn as an official university’s own VLE (built on WebCT LMS) for several years and now they switched to Desire2Learn VLE in summer 2012 due to the limitations of the current system and the additional features in the new one.

Additionally, some universities are using their own Learning system such as the Open University in the UK but very recently even they have switched to Moodle (Moodle website). The Open University runs the majority of their courses online. They are the UK’s largest university and double the size of University of London as the availably of their courses’ materials online although they teach most of the courses online (Online education, 2011). It is considered one of the first educational institutions that applied e-Learning concepts. The first use of this concept from this university was in 1971 when they started to broadcast some courses on TV (Online education, 2011).

Recently, some VLEs have extended their scope to include other organisations as well as universities. They have been tending to be more used outside universities. For instance, some training or development centres started using VLEs to offer some training courses online. For instance, financial and banking organisations can use VLEs by providing training materials (e.g. word documents or PowerPoint slides) or using the other features such as blogs, forums or chat rooms to provide a help desk services online (Nair, 2010).

Finally, to summarise the benefits of VLEs, it is the way to go for organisations whether educational or non-educational institutions that would like to deliver dynamic and static information to interact with their stakeholders and clients (Nair, 2010). However, the big question that is emerging now is; what is the next generation and development of e-Learning? And what is the new technology that can be integrated with the current learning systems to enhance students experience within these
platforms? Recently, several research projects have been investigated this issue of how can we develop the current learning systems and move them to another generation? Some researchers have reached to the conclusion that we can improve the current learning systems by implementing the idea of the future web, which is “Semantic Web technologies” (Sampson, Lytras & Wagner, 2004).

1.2 Web 2.0 and Web 3.0 tools
The Web has passed through different stages of development since its appearance such as Web 2.0 and Web 3.0 as Figure 1 shows. In 1990s, the first generation of the World Wide Web started to present limited content types such as images and texts to the web users in a read-only form. This first generation of the web is called Web 1.0 (Rosati & Mayernik, 2013). Web 2.0 has appeared later, which allows web users to interact and collaborate to each other in a read/write form such as live chat customer service. With Web 2.0, everyday web users interact with the web as a platform to read, edit and write shared content (Franklin & Harmelen, 2007). The first use of this version of the web was in 2004 by Dale Dougherty, a vice-president of O’Reilly Media Inc., to refer to the second generation of web-based services, which focuses on online sharing, interaction and collaboration (Collis & Moonen, 2008) (Andersen, 2007).

![Figure 1: Evolution of the web](Source: Nova Spivack and Radar Networks)

There are many examples of the use of this version of the web such as social networking and media sites, blogs, news feeds, wikis and video hosting sites. The
visible use of Web 2.0 tools by the majority of web users are the social networking and media sites (e.g., Facebook, Twitter, LinkedIn, Flicker and YouTube). It can provide clearly the interaction, collaboration and sharing of content between the users of these sites. The authors of the content are the users themselves of these sites unlike Web 1.0 where only few content authors are responsible to produce the content of the web. For instance, Facebook, YouTube and other social media sites rely on user-supplied content to operate their sites. Further details about Web 2.0 tools and its recent applications in education will be discussed in the next chapter.

After that, the new term Web 3.0 has appeared in order to bridge the gap between computer applications and human web users due to the lack of machine interpretable semantics for objects and data that were published using Web 1.0 and Web 2.0 tools (Rosati & Mayernik, 2013). This was considered one of the largest challenges of the first two versions of the web for web applications. For example, search engines cannot understand the data on the web and provide a context to this data. The content of the web is only understandable by human web users and not applicable for computer applications in the first two versions of the web. Through the use of the semantic data, the content of the web will be displayed in a form that is human and web/computer applications readable (Rosati & Mayernik, 2013). In the following subsection, we define and introduce the semantic web. Further details about the semantic web applications will be discussed in the next chapter.

1.2.1 Semantic Web

Tim Berners-Lee predicted that the next version of the web would be the Semantic Web (Berners-Lee & Fischetti, 1999). The Semantic Web aims to enhance the web with semantic pages that offer a knowledgeable level of searching and querying (Omelayenko, 2001). There are several definitions of semantic web but we have chosen this one by Schwartz because it has been used in many papers. According to Schwartz, the Semantic Web is:

“Meant to enable an environment in which independent, Internet-connected information systems can exchange knowledge and action specifications”

(Schwartz, 2003)

It is expected to be the next generation of the web that allows expressing information in a precise, machine understandable form to understand the terms that explain the data meaning (Devedžić, 2004).
In addition, semantic web depends on heavily formal ontologies structure (e.g., FOAF, SIOC and DC) to keep the data in structured form (Maedche & Staab, 2001). Ontology is the way to represent the data in the semantic web (Abel, 2004). It can be used to specify the meaning of the data and index the data (Abel, 2004). In general, an ontology is a representation of a shared conceptualisation of a particular domain (Sampson, Lytras & Wagner, 2004). It is considered as a major part of the semantic web. Therefore, as the semantic web supports the sharing and reusing of content, this can give a significant power to support e-Learning services. VLEs can benefit from that to develop the current learning systems and move them to another generation of development.

1.3 Moving Towards Open Education

Nowadays, the openness of learning content within the web can be seen widely, especially after the innovation of the Massive Open Online Courses (MOOCs) such as Coursera and Udemy. MOOCs are web-based teaching programs offered to thousands of students (Waldrop, 2013). Much of the learning relies on online educational material such as video lectures. The importance and the success of these open online courses is clearly visible now despite the very recent appearance of these courses. For example, Stanford University is taking the lead to offer MOOCs compared with other educational institutions, in addition to their physical courses. By late 2011, MOOCs had attracted the eyes of learners and educational institutions after the significant success of the free open online course “artificial-intelligence” that was then offered by Stanford University. After just one public announcement, this course attracted more than 160,000 people from around the world additionally to 200 students who enrolled in the physical lectures of this course (Waldrop, 2013). Currently, Stanford University offers several MOOCs in parallel with their on-campus courses in order to bring the quality of their teaching to people who would be not able to come to Stanford and pay the full fees to enroll at the university.

In addition, educational institutions including universities and colleges can enhance their economic situation by offering these open online courses with some affordable fees as they can attract more people to their courses. For instance, when one lecturer can teach 100,000 learners in the same time, of course, this will significantly increase the number of people who interact with universities. The clear success of MOOCs in the past few years has already shown educational institutions the benefit of offering
these open courses online with some additional effort and potentially large profits (Waldrop, 2013). Given that most universities around the world already using VLEs to store their educational materials including course contents, opening their courses (or VLEs) entails relatively little additional effort in order to attract more people as mentioned with Stanford University. However, an important challenge will emerge as the availability of open online courses increases. In order to build an open ecosystem of online educational material, there needs to be a mechanism for finding open course content online accurately. This points us towards the potential benefit to the finding of learning content from the advantages of the semantic web. It can facilitate finding of learning contents from these open courses or VLEs in general in a more meaningful way as the semantic web aims to make the content of web in a machine-readable format as mentioned in the previous section. We will discuss this more in the rest of this thesis.

1.4 Research Hypothesis

As we have mentioned, there has been less development in the current VLEs in the past few years even though the web has been developing (e.g., Web 2.0, Web 3.0). In this research, we will investigate how can we make VLEs more attractive and collaborative to students and teachers. Our main motivation in this thesis project is to investigate the sharing of knowledge and data in an educational context, and to make VLEs more open and collaborative for educational and non-educational institutions. In order to achieve that we will explore in this research if the semantic web can support our aims to make these changes; as it is expected for the semantic web to develop the next generation of learning systems (Sampson, Lytras & Wagner, 2004).

From this point, we can create our research hypothesis that if the semantic web can enhance VLEs and make a real development in this field to give VLEs significant power of improvement. This requires a deep investigation to see whether there are current examples that use the semantic web in education. This will be discussed in the upcoming chapter and then we can identify the chances of development in VLEs. In addition, we explore the addition of features and functions to provide enhanced multimedia and social networking support for VLEs and demonstrate the potential for development in these environments by integrating new technologies.
1.5 Research publications

1.5.1 Journal Papers

1.5.2 Conference Papers


1.5.3 Conference Oral Presentations


1.5.4 International Competitions

1.5.5 Summer Schools
Participating at the 9th Joint European Summer School on Technology Enhanced Learning (27th-31st May 2013, Limassol, Cyprus), which has variety of practical and methodological workshops and lectures as well as opportunity to have access to experts in my field.

1.6 Structure of the thesis
This thesis project is structured into eight chapters. We already started in this chapter with a broad introduction of the general terms used in this thesis project and the research hypothesis. The next chapter focuses mainly on the literature review and background of this thesis project. It discusses mainly the recent and related work in semantic web and Web 2.0 tools. It ends with analysing the challenges and potentials
of this research and then the research question can be created. After that, chapter 3 aims to cover the technology base (semantic markup formats, schema.org and Drupal CMS) that is used to implement this demonstration VLE. Next, chapter 4 discusses the core design of our VLE architecture in depth. It also describes the social and media features that have been added to the prototyped VLE. Further, chapter 5 focuses on our proposal to schema.org by proposing new vocabularies to describe VLEs content with rich semantic information. Following that, an evaluation of the VLE functions that already presented in the previous chapters of this thesis project is discussed in chapter 6. Finally, this thesis project ends with the future work and the final conclusion that will be discussed in chapter 7 and 8.
2 Background and Related Work

This chapter focuses mainly on the literature review. First, it will provide an overview for the most popular learning systems that have been used recently. Next, it will discuss the development of the Semantic Web and its early applications especially in the education field. After that, it will discuss the recent and related work in semantic web, social networking and media. Finally, the research question can be created after this literature review and analysing the challenges and potentials.

2.1 The current learning systems

In this section, we will give an overview of some of the conventional learning systems and their features including commercial and open source environments that are considered from the most used systems among education institutions in the past few years.

2.1.1 WebCT

WebCT is an online proprietary VLE that is sold to several universities and other education institutions worldwide for e-Learning services. It was the first successful VLE system and has been used in 80 countries and by more than 10 million students around the world (Britain & Liber, 2004). The course instructor can create many sequential activity structures (e.g., content page, discussion chat, whiteboards, syllables, media library objects and assessment tools). Also, it is possible to create student groups and change the groups as well. This gives the lecturer the facility to create assignment workgroups and allocate specific materials for each group. However, webCT is owned now by Blackboard Inc; it was acquired by its rival Blackboard in 2006 (Blackboard, 2014).

The University of Surrey used the WebCT VLE for several years. They call their VLE ULearn, which is part of WebCT. Recently, the university has switched to new similar VLE, which is Desire2Learn due it being more attractive for students and the limitations of the previous system.

2.1.2 Blackboard

The Blackboard learning system is a course management system (CMS) and a VLE, which has been developed by Blackboard Inc (Britain & Liber, 2004). It is a web-based platform server. It can be installed on a local server or hosted by one of
Blackboard’s servers. It has two main purposes: first, add any contents and materials online for any traditional course that are delivered face-to-face. Second, develop whole online courses that can be delivered with no or few face-to-face lectures. In addition, it can be accessed from the Internet anywhere and anytime similar to most other VLEs. Therefore, students can access to their course materials (e.g. lectures notes, slides, audio/visual aides and assignments) from their machines. Also, students can submit their assignments online anytime and anywhere within the deadline that the course instructor identified.

2.1.3 COSE (Creation of Study Environments)
COSE is a virtual learning environment that was designed at Staffordshire University, which grew out of research project (Britain & Liber, 2004). It was developed to support active learning models. The main design for this system is to create the contents by students and lecturers. In this system, students have available the same roles and tools for lectures. They can create content from their own materials or re-assemble the resources that they have found. In COSE, the contents are assigned to people and not people assigned to content (Britain & Liber, 2004). This system encourages students to join groups, search and share for additional resources either internal or external. It supports a flexible structure of people with their groups to facilitate collaborative work.

2.1.4 Claroline
Claroline was created and designed by a French university which was interested in creating an open-source platform for VLEs that could be an alternative to Blackboard (Clements, 2003). Claroline is a course web-based learning tool allowing the lecturer to create, feed and administrate courses through the web. They said that their approach is different comparing with other VLEs; courses are divided into component elements and published on the site under separate places (exercise, chats, links, announcements and resources). Therefore, the course instructor can choose which element and tool can be displayed to students via a simple interface screen. It has a simple interface system comparing with other VLEs. Students can upload their papers to the system for peer review. The system allows uploading video files that can be used as resources for the course. At the time this was the only system with a specific
video-handling feature, but others could be adapted to allow for the use of this media in courses (Clements, 2003).

2.1.5 ATutor

ATutor is an open-source web-based VLE which was developed by Toronto University in Canada (Clements, 2003). It has expanded to cover many universities in the world and it still is free. It enables the course instructor to create any course with several content pages, similar to the Claroline system. It has an export feature, which allows transferring the content for courses that have been created in the system. This is a unique feature for this system as no other systems mentioned that (Clements, 2003). Furthermore, it has an accessibility feature, which is another unique feature that can support learners with disabilities (ATutor, 2015). It has also most of the VLE features that are described above. It supports different technologies (e.g. PDAs, cell phones and text-based web browsers) that allow users to access the system (ATutor, 2015). However, it requires course instructors to have basic HTML skills although it has a very simple design. It allows a course instructor to edit the themes easily by customising the layout and look of the pages to their specific needs.

2.1.6 ILIAS

ILIAS stands for Integrated Learning Information and co-operAtion System. It is an open source web-based and learning management system (LMS). It has been developed by the university of Cologne as part of the Virtus project. ILIAS has several tools for information access, authoring, co-operative work and learning (Itmazi, Megías, Paderewski, & Vela, 2005). ILIAS course instructors can create courses within a team and publish their learning contents on the web. Furthermore, students are able to create groups to work on course materials and can communicate to each other. The main features of ILIAS as a learning environment are: search engine, tests, print function, personal desktop for each user and personal annotation (Itmazi et al., 2005). ILIAS has gained a good evaluation in some studies. More than 115 organisations from 18 countries are using it and it has been translated to 16 languages (Itmazi et al., 2005).

2.1.7 MOODLE

Moodle stands for Modular Object-Oriented Dynamic Learning Environment. It is an open source web-based VLE that is very similar to other commercial learning
systems. It was originally written and developed by a PhD student called Martin Dougiamas who was interested in exploring social constructionism (Britain & Liber, 2004). The main difference between Moodle and the other commercial systems is its roots in Social Constructionism that support constructivist learning and other common features that correct the limitations of the other commercial systems (Britain & Liber, 2004). Moodle is very large learning environment. By November 2011, it served 57,189,081 users in 5,846,949 courses with 72,072 sites in 223 countries and in more than 75 languages (Moodle statistic, 2015).

However, Moodle has a number of distinguishing features compared with the other commercial systems. The most important difference is that it is open source and free. It has a community of educational practitioners and developers on Moodle site. Therefore, it is a customisable and affordable leaning environment product especially for small education institutions such as schools, small colleges or individual lecturers and departments that do not have enough budgets for a license to set up e-Learning courses using a commercial product (Britain & Liber, 2004). Further, Moodle has a number of constructive tools such as peer group assessments, the ability to rate posts and reflective journals (Britain & Liber, 2004). It has also more features that might be available in other e-Learning platforms, which we can summarise in the following points (Clements, 2003):

- Allowing students to upload their learning materials to share them with other students.
- Layout of the system pages can be fully customised for specific courses.
- Creating a variety of surveys.
- Offering administrators and students to change the feel & look of the sites without asking a new style sheet.
- Online calendar.
- Online quiz, announcements and news.
- Discussion forum.

### 2.2 Evaluation of the current learning systems

To our knowledge, there is a lack of evaluation for the available LMSs or VLEs. It has been also mentioned by Graf and List that there are only few learning environment evaluations available (2005). Furthermore, most of these learning environment evaluations are concerning about their functionality and performance
rather than their limitations and challenges. However, we will discuss in this section some of these evaluations about the current e-Learning platforms; either open source or commercial learning environments after summarising the most important features and limitations of the conventional VLEs that just described in the previous section. Moodle, COSE and ILIAS provide a good support for collaborative learning such as creating joint groups between students. Also, another important feature is the media support. Claroline is an example of these VLEs that has a support of media as mentioned in the previous section. On the other hand, the most important limitation of these systems is the lack of openness of these environments’ content as we described in Chapter 1, the need of keeping learning resources open to the web such as MOOCs. Another limitation is that none of these platforms have semantic features support. Regarding the existing evaluations of these learning platforms, Graf and List conducted an evaluation against nine popular open-source LMSs such as Moodle, ATutor, Dokeos and ILIAS (2005). This evaluation compared these learning environments regarding the following functions: communication tools, learning objects, management of user data, usability, adaptation, technical aspects, administration and course management in order to identify the most suitable open-source LMSs. Moodle achieved the best evaluation in most of the above functionality against other open-source LMSs. Also, ILIAS and Dokeos achieved the second and third rank in this evaluation. Furthermore, another research study performed a general comparison of the characters of the famous open source LMSs Moodle and ILIAS including their features and weaknesses (Itmazi et al., 2005). Moodle and ILIAS shared some weaknesses as mentioned in this evaluation. For example, there is no facility to share or reuse course content. Also, they do not have video services to enable course instructors to run stream video. Other shared weaknesses in Moodle and ILIAS concern the lack of a recommendation system tool and absence of support for curriculum management. This is a really useful evaluation as it mentioned some limitations in the top LMSs as recommendations for further development in these systems. On the other hand, there are also some evaluations for the commercial e-Learning platforms. For instance, O'Droma, Ganchev and McDonnell performed an evaluation of ten leading commercial e-Learning platforms about their functionality (2003). This evaluation covered several aspects of these VLEs’ functionality such as administration, assessment, learner information, course configuration, and interaction
context. Their judgement was that Blackboard lead the top commercial learning environments mentioned in this paper, based on the above assessment of functionality.

Furthermore, another research paper performed a general purpose evaluation for the most known commercial e-Learning platforms such as Blackboard, WebCt and Learning Space (Colace, Santo, & Vento, 2003). This evaluation was performed based on the LMSs’ usability and functionality. Basically, this evaluation performed two assessment scenarios. The first assessment of this evaluation indicated the availability of the services such as E-Mail, virtual classroom, discussion board and whiteboard in these LMSs. The second assessment focused on the use of the available functionalities within these systems such as new course creation, test creation, reports on test results, on-line registration, students’ group creation and progress tracking. Overall, Learning Space was the best LMS in accordance with this evaluation. Furthermore, Centra-Cisco, Click2learn, Topclass, Blackboard and WebCt achieved significant results in accordance with assessment criteria in this evaluation.

As we have seen above, most of these evaluations are concern with deciding what is the best LMS based on the comparison in each evaluation of the available functions in each environment. On the other hand, Itmazi provided a different evaluation form as it mentioned some of the limitations (e.g., share/reuse content, video services, recommendation system tool and curriculum management) and also the features of the top open source LMSs Moodle and ILIAS (Itmazi et al., 2005). However, there has been also a lack of development in the conventional VLEs in the past few years and they just focus on adding some extra features or avoiding some limitations in other systems as we have seen in the previous section. This is due to the stability of their performance is working against the development of these learning environments and introduction of new innovations (García-Peñalvo & Conde, 2011). Therefore, García-Peñalvo and Conde stated that VLEs should become flexible and open learning environments and not ignore new tools and trends (2011).

The current learning systems need a significant development to move these environments to a new generation of VLEs. The expectation for the new generation of VLEs is to use the context of semantic web technology in terms of developing e-Learning (Sampson, Lytras & Wagner, 2004). Nowadays, sharing and reusing educational resources is becoming a hot topic and a main focus of the technology-enhanced learning (TEL) community (Dietze & Sanchez-Alonso, 2013). Therefore, in
the next section, we will provide an overview of the new innovations and tools that can be integrated into VLEs in order to make a significant development in these environments.

2.3 Semantic Web Growth

The World Wide Web was originally designed for humans to read, not to be machine-readable in a meaningful context. Nowadays, the web has been developing through the emergence of the semantic web to publish machine-understandable information in the web. We see this most pertinently with the increasing use of Schema.org by organisations such as e-Bay and the BBC. The semantic web or web of data is also used to facilitate reusing and sharing of data on the web (Berners-Lee, Fischetti, & Michael, 2000), (Bizer, Heath, & Berners-Lee, 2009) and (Bratsas, Bamidis, Dimou, Antoniou, & Ioannidis, 2012). Furthermore, semantic web technologies have passed through different stages of development since their appearance. This section will provide an overview about some applications and research projects of the semantic web through different stages of its development. First, we discuss some early examples that used the semantic web for learning purposes. They are few and most of them are case studies although the semantic web has many uses in non-education environments. After that, we discuss the recent and current developments in Semantic Web.

2.3.1 The early applications of Semantic Web

Most the following applications and research projects use the semantic web for only a part in e-Learning such as searching, authoring or structuring in the context of learning. After that, we will discuss the recent and current development of the semantic web in the following sections.

2.3.1.1 LAOS (Layered AHS Authoring-Model and Operators)

LAOS is a generalised authoring model for dynamic adaptive hypermedia frameworks (authoring system). It was developed to see if it is possible to convert from an adaptive educational hypermedia model to the semantic web language. It consists of five layers (Cristea, 2004):

- **Domain model:** contains a list of linked resources.
- **Goal and constraints model:** contains goal-related and constraints information.
- **User model**: contains information about the learner.
- **Adaption model**: contains the behaviour (e.g. learning style).
- **Presentation model**: contains machine-related and display information (e.g. the background colour scheme).

In addition, the main goals of LAOS are (Cristea, 2004):

- **Flexibility**: semantically meaningful data of different combinations, which could be created by the automatic population of the different layers of the LAOS framework.
- **Expressivity**: the elements of the model should be machine understandable and also easy to understand for humans.
- **Reusability**: to allow reuse of all concepts of the adaptive educational hypermedia (AEH).
- **Non-redundancy**: to avoid the creation of the same element more than once.
- **Cooperation**: to support the collaboration of different authors.
- **Inter-operability**: the authoring of AEH should easily be able to move material into other AEH platforms.
- **Standardization**: it should extract and explain patterns at different levels of detail.

These goals of LOAS are similar to the goals of the semantic web (flexibility, expressivity, reusability, non-redundancy, cooperation, inter-operability, and standardization) (Cristea, 2004). However, the semantic web has an additional goal of making the web accessible to all (Cristea, 2004). Overall, the concepts of LOAS are compatible with the semantic web. Therefore, Cristea has implemented the LOAS framework with the standard semantic web language (XML language) in order to prove that framework.

### 2.3.1.2 MOT (My Online Teacher)

MOT is an adaptive educational hypermedia (authoring systems) based on LOAS. As MOT was developed based on LOAS, it has been built on the same five layers (domain model, goal and constraints model, user model, adaption model, and presentation model) (Cristea, 2004). Furthermore, it confirms to the LOAS principles and inherits the layers from the LOAS framework. However, Cristea has expressed the MOT framework in the semantic web language, as it is compatible with the
concepts of the semantic web but this time implemented with RDF instead of pure XML.

2.3.1.3 O4E Web Portal

Ontology for education (O4E) is a web portal, which provides a single network place that allows students, researchers and practitioners to find information about the available research projects in the education field (Dicheva, Sosnovsky, Gavrilova, & Brusilovsky, 2005). They collected the available information in the field and classified the information items to build the O4E portal. The result was the development of an ontology for educational content, which is one approach to moving towards the semantic web.

The initial idea of this system was to design a portal containing a graphical representation of the ontology that had been developed with an index page to link all materials and resources that were collected (Dicheva et al., 2005). After building the first version of the portal, they started to represent the ontology in a sharable, interoperable and exchangeable format. Meanwhile, it can be simply merged, moved and updated for its further development and survival. They represent their ontology by Topic Map (TM), which is a semantic web tool. They chose TM as it is appropriate for formalizing the lightweight ontologies and for representing ontology of web-based information (Dicheva et al., 2005). They used TM4L (Topic Maps for e-Learning) for its development, which is an environment that supports creating and using ontologies of online learning materials. It consists of two tools: TM viewer and TM editor. If the user chooses a specific resource type, all the instances of that type will be listed in a tree view. For instance, when the user selects any specific resource, it will show for the user all workshops, researches papers, presentations and conferences in a tree view as shown in Figure 2.
2.3.1.4 PIP (Personalized Instruction Planner)

PIP has been designed and implemented based on PEOnt (Personalized Education Ontology) framework (Fok & Ip, 2007). Figure 3 shows the PEOnt framework and its five interrelated educational ontologies. PIP is a web-based ontology editor for teachers to improve/strengthen the teaching quality through a sharable, common infrastructure (Fok & Ip, 2007). However, the current implementation for PIP is focused on English language learning in primary school education. PIP has five main features that support the system and provide personalized instruction planning: (Fok & Ip, 2007)

1. Administrative functions: the functions in PIP are restricted for administrators as any change can be affected on the ontology schema.
2. Create or design a curriculum based on the PEOnt framework.
3. Create or design instruction plans based on the PEOnt framework: to facilitate teachers through the process of the instruction design.
4. Maintain user profile.
5. Searching: it provides for teachers two options of searching: global searching to search for educational materials on the web and local searching to search locally inside the system such as looking for a particular model or learning activity.
In addition, there are some general applications of semantic web or linked data, which can be also used in learning context that will be discussed below.

### 2.3.1.5 Falcons and SWSE

Falcons and SWSE are a human-oriented search engines that provide search services to human users based on the semantic languages (RDF and SPARQL) (Bizer et al., 2009). They have a more detailed interface for the user to simplify the structure of the data compared with other existing market leaders. Falcons provides users three choices of searching: objects, concepts and documents as Figure 4 shows. Each one has a slightly different presentation of results. For instance, object search is to search about people and places, concept search is to search for classes and properties in ontologies on the web, document search has more features to search for documents as its results link to RDF documents which have the specified search terms (Bizer et al., 2009). On the other hand, SWSE provides access to its underlying data structure by the SPARQL query language. However, SWSE currently does not support the normal users that ask very detailed questions but it is suitable now for applications developers that have a good knowledge of the language.
2.3.1.6 DBpedia

DBpedia is a team effort that extracts structural information from Wikipedia and makes it available on the Internet. It does this by converting the data into RDF and making it simply available on the web (DBpedia, 2015). This will allow users of the web to ask sophisticated queries to Wikipedia. We can describe DBpedia as the semantic mirror of Wikipedia.

2.3.2 The recent development of Semantic Web

The past section discussed the early developments in semantic web technologies. This section discusses the recent semantic web or linked data development. The recent semantic web applications use mostly specific formats (e.g., RDF, XML, etc.) with formal vocabularies, schemas or ontologies (e.g., FOAF, SIOC, DC, SKOS, etc.) to describe resources and content in semantic form and their relationships with other sites. Each ontology has its specific uses, scope, classes and properties to describe the data with RDF. We will discuss briefly the most popular used ontologies/vocabularies and the recent applications in this section.
2.3.2.1 **Friend Of A Friend (FOAF)**

The Friend Of A Friend (FOAF) ontology is used to represent the data of social networks in a machine-readable and shared way (Bojars, Breslin, & Decker, 2008). It is an ontology to describe people and the relationships that they share on the web (Good Ontologies, 2010). The FOAF ontology is used, for instance, to represent faculty, staff and students (Bratsas et al., 2012). It is well suited for use with social platforms (e.g., Facebook, twitter and Blogpost) (Good Ontologies, 2010). Furthermore, FOAF allows us to describe personal profiles as well as representing relationships between people (Good Ontologies, 2010). Currently, some social platforms like Facebook, Flicker or Twitter make their users’ profiles available in RDF using FOAF.

2.3.2.2 **The Semantically Interconnected Online Communities (SIOC)**

The Semantically Interconnected Online Communities (SIOC) ontology is used to describe and link discussion posts within online community sites such as blogs, wikis and forums (Bojars et al., 2008). It provides a semantic ontology to represent rich semantic data in RDF within the social web. SIOC complements the FOAF ontology by stressing the description of those communities such as posts and replies (Good Ontologies, 2010). SIOC allows to link user created content to people, topics and other related items. It can represent various types of content: Wikis; Blogs; Board posts. It can also represent contents such as ImagGallery (Bojars et al., 2008).

2.3.2.3 **Dublin Core (DC)**

The Dublin Core (DC) ontology is a lightweight RDF schema for describing generic metadata (Good Ontologies, 2010). It provides metadata vocabularies to manage and discover resources. It can be used to describe a wide range of web resources: web pages, videos, images etc. The DC ontology can be used for describing simple resources to provide interoperability for metadata vocabularies in semantic data or linked data.

2.3.2.4 **The Simple Knowledge Organisation System (SKOS)**

SKOS is used to express the basic content and structure of concept schemes (taxonomies, classification schemes, thesauri, terminologies and other types of controlled vocabulary) (SKOS Core Guide, 2005). Its goal is to provide a simple framework for expressing knowledge in a machine-understandable way. SKOS is
built upon RDF that allows to share and link knowledge organisation systems over the Semantic Web (SKOS Core Guide, 2005).

In addition, there are specific educational standards such as Shareable Content Object Reference Model (SCORM) and Learning Object Metadata (LOM), which are already used by typical LMSs to support the reuse of data with other learning environments. These ontologies have been used with many research projects and applications in the past few years in the context of linked data.

A recent work has its own schema, which is the Bowlogna Ontology based on Linked Data (Demartini, Enchev, Gapany, & Cudré-Mauroux, 2013). It supports the exchange of information across Europe’s higher education institutions. It helps students across Europe to search and join external courses in other universities. The Bowlogna Ontology enables the connection and sharing of information among education systems by maintaining the description of curricula available for each institution even in different human languages such as English, French and German. Another example of using Linked Data with available educational resources is the “mEducator” project (mEducator, 2015). It links educational resources and enables medical content to be shared, discovered and reused across European higher academic institutions.

Furthermore, educational institutions began to maintain their data freely available on the web based on Linked Data; for instance, the Open University (OU) in the UK (Open University, 2015). These data include: course descriptions, open research online and OU podcasts. In addition, the Southampton Learning Environment (SLE) project is another example of educational institutions attempting to integrate e-Learning environments to semantic web technologies. The SLE project was planning to provide a rich learning environment based on linked data approach to be freely open on the web (SLE, 2015).

2.3.3 The current development of Semantic Web

The latest development in the semantic web is the semantic annotation/markup of the web content. It uses a special format to markup the web content by embedding a rich semantic description within the HTML code to publish documents on the web that both machines and humans can understand. The three major semantic markup formats for embedding semantics in HTML documents that have the current focus are: RDFa, microdata and microformats (Adams & Councils, 2012). The major search engines
have supported these formats in some fashion in the past few years (Ronallo, 2012). Further details about these formats are discussed in the next chapter. Search engine providers want to keep the context of semantic annotation simple in order to make it easier for webmasters to markup their webpages with rich semantic information due the complexity of implementing semantic markup in the past few years (Ronallo, 2012).

Very recently, there has been an obvious focus on the use of semantic markup or semantic annotation especially after the innovation of schema.org, which is a joint effort between the major search engines, Bing, Google, Yahoo! and Yandex, to have a global, broad and official ontology or vocabulary that can be understood by the big search engines. Therefore, this is a very powerful advantage to this schema instead of other ontologies or vocabularies as it has support from the major search engines. This is a really pragmatic decision from the big search engines to have a unique, web-scale and broad vocabulary that is supported by them, as it is unrealistic to support every vocabulary in use. schema.org uses HTML5 elements to embed rich semantic information within the webpage’s HTML code. Therefore, this rich semantic information will not only help search engines to provide more accurate results but also return more meaningful information. We will discuss very recent applications and research projects that use semantic markup with schema.org in the next section.

2.4 Related Work

To understand the research aims, we provide in this section a general overview of related work to show the overall challenges and problems that are related to this research. We will focus more on the recent and active research in the area of technology-enhanced learning (TEL). Sharing, discovering and reusing educational resources and data to be freely available on the web is the most active research area by the TEL community and has been focused on in the past few years (Dietze & Sanchez-Alonso, 2013).

A peer-to-peer architecture (LOP2P) is an early example of reusing and sharing educational resources (de Santiago & Raabe, 2010). This peer-to-peer architecture allows participating educational institutions to share their learning resources with the others through a single network (LOP2P) by creating courses based on the learning object repositories using a particular LOP2P plugin that connects to a Learning Management System (LMS). Another similar example P2P architecture is to integrate
the EduLearn project with Learning Object Repositories (LORs) for sharing learning objects and enhance the reusability of educational contents using a Semantic Overlay Network and P2P architecture (Prakash, Saini, & Kutti, 2009).

In addition, due to the limitations of P2P networks, more recent research is exploring the significant advantages of semantic web technologies and web 2.0 tools to improve the sharing, discovering and reusing of educational resources. However, this section will discuss some recent examples of semantic markup with schema.org regarding the semantic web technologies part, as we have discussed broad examples of semantic web technologies earlier in this chapter. The second part of this section will discuss the use Web 2.0 tools in e-Learning platforms.

2.4.1 Semantic markup and Schema.org

Several researchers have recently focused on structuring the data on the web based on semantic markup and using supported vocabularies (schema.org) that can be understood by the existing search engines to enhance the discoverability and visibility of web contents. In addition, the importance and success of schema.org is clearly visible now, as it has been used widely in many applications and research projects in the past few years, as reported in the statistics contained in (Mika & Potter, 2012) and (Mühleisen & Bizer, 2012).

2.4.1.1 UK Open Educational Resources (UKOER)

A very recent research is the UKOER project; their approach is to add semantic markup to their education resources using schema.org vocabularies in order to enhance the discoverability of education resources and to be freely available on the web (Hawkssey, Barker, & Campbell, 2013). The reason behind using schema.org is that most people will use search engines to search for open education resources (OERs) as they stated. Therefore, it would be valuable to describe OERs using schema.org vocabularies to ensure that their educational resources display prominently in search engine results. They have also mentioned in their approach to using microdata format; the preferred semantic markup format by search engines to describe their resources by schema.org vocabularies. Their approach aims also to benefit from the new learning resource vocabularies that have been added to the schema very recently by the Learning Resource Metadata Initiative (LRMI) to describe their learning resources.
2.4.1.2 Facilitating data discovery

Rosati and Mayernik have used schema.org with the semantic markup format microdata in their first approach to markup their webpages to increase the discoverability and connectivity of their resources in the web (2013). The second approach is to use RDF/XML, the semantic web data structure with the Open Archives Initiative Object Reuse and Exchange (OAI-ORE) (Rosati & Mayernik, 2013). They have used these two markup approaches in three different case studies within geosciences in order to evaluate their applicability to markup research data archives. Their evaluation is based on four factors of each markup approach: ease of use, the available standards and vocabularies, the ease of interoperability, and the relation to data citation tools and methods.

They have found for the ease of use factor that any webmaster can use microdata with schema.org. In contrast, RDF requires a high degree of knowledge to be implemented due to its complexity. In terms of availability of standards and vocabularies, they have found that RDF is a general-purpose tool. On the other hand, they found that schema.org vocabularies are small, constrained and simple in their three case studies topics. They mentioned that they used the generic type “Thing” and “CreativeWork” in schema.org due to the lack of support for academic vocabularies in the schema, as the schema has been lacking of support in specific vocabularies for academia until April 2013. In terms of ease of interoperability, both RDF and microdata are significantly in use and their vocabularies are growing fast for both them. Furthermore, microdata is an important part of HTML5, which can give another advantage to schema.org and microdata. In terms of relation to data citation tools and methodologies, RDF applications can be more easily leveraged than schema.org applications in the data citation metadata XML “DateCite”. The authors believe that the reason for some of the limitations that they mentioned above about schema.org is due to the schema being still in early development despite it having been growing in usage.

2.4.1.3 Mapping Schema.org and web of Linked data

This research discussed the possibility of mapping schema.org terms and terms in the web of Linked data (Nogales, Sicilia, García-Barriocanal, & Sánchez-Alonso, 2013). The authors provided different examples of the mapping for the most popular classes and properties (e.g., Event, Person, Organization, Country, Language) between
schema.org and Linked data terms. Their results showed that it is easier to allocate a mapping between classes than among properties for schema.org terms and terms of Linked data. This research also gives a broad overview of the recent applications and research projects of schema.org with a good feedback about this new innovation.

In addition, schema.org has been used to describe and annotate media using schema.org terms as it has support for describing media (e.g., video, audio, etc.) with semantic information. For example, recent research proposed an application to publish and describe video fragments with semantic terms defined in schema.org following linked data principles (Li, Wald, Omitola, Shadbolt, & Wills, 2012). Another very recent research to enrich webpages with semantic information by using semantic markup with schema.org is discussed in (Krutil et al., 2012). This research shows some examples of using schema.org to enrich webpages with semantic information basically in Recipes vocabularies. The authors are quite optimistic about the future of the web with schema.org. Also, all the previous works mentioned above have a quite positive feedback of using a broad and supported ontology “schema.org” instead of using other focused ontologies in specific fields to embed their webpages and resources with rich semantic information.

In addition, schema.org has been used in many commercial webpages in different areas such as Products, Events, Applications, Movies, Music, Recipes, Reviews and TV series. For example, the famous online shopping site “eBay” is using schema.org vocabularies to describe its products with rich semantic information to allow search engines to understand its data in a meaningful way. Therefore, this rich semantic information will not only help search engines to provide more accurate results for these commercial sites but also return more meaningful information. It will also help search engines to display rich snippets by highlighting the most important information, which appears under each search result to give users a sense for what is on the page.

2.4.1.4 Rich Snippets examples

Figure 5 shows an eBay product in search results with rich snippets by highlighting the most important information of this product. This can also help users to decide whether this site is relevant to their search by looking to the rich snippets.
Figure 5: Rich Snippets in search results for specific product in eBay

An example of rich snippets can be seen also in “YouTube”. The big social media site is using schema.org vocabularies to describe its videos in rich semantic information to allow search engines understand its data in a meaningful way. This allows search engines to show rich snippets of their videos in search results by highlighting the most important information of each video such as the title, URL, the thumbnail photo of the video, duration of the video, uploaded time and who did upload it, as Figure 6 shows.

Figure 6: Rich Snippets in search results for a YouTube video

In addition, the professional social network “LinkedIn” includes a semantic markup of data in their user profiles in order to allow search engines to extract this information and show it in rich snippets in search results as shown in Figure 7. Currently, Google only supports rich snippets for the following types in schema.org: People; Products; Events; Authors; Applications; Movies; Music; Recipes; Reviews; TV series (Ronallo, 2012).
2.4.1.5 Semantic markup tools

There have been some attempts to create tools to automatically enrich webpages with semantic information based on schema.org vocabularies in order to facilitate the embedding of semantic information. Ambiah and Lukose proposed a tool called schema.org Microdata Creator (ScheMicCr) to automatically generating schema.org vocabularies with microdata to enrich webpages with semantic information (2012). ScheMicCr is able to enrich webpages in two different scenarios. The first scenario is to enrich existing webpages with microdata. In contrast, the second scenario is to generate new webpages with microdata. Both scenarios are using schema.org vocabularies to be easier for search engines to create a semantic index. They have tested this tool with an experiment, which focuses on enriching webpages with semantic information for patent information. They have also compared ScheMicCr with other five existing microdata creators (microData Generator, RDF2Microdata Converter, SchemaCreator, SchemFied and HTML5 Microdata Template) in terms of an evaluation of this proposed tool. The key advantage of ScheMicCr over the other existing microdata creators is enriching existing webpages with semantic information, not only generating new webpages with microdata.

In addition, Khalili and Auer have proposed an interface tool to automatically facilitate the authoring and publishing process of structuring web content with semantic information due the lack of user-friendly tools for this purpose as they stated (2013). Their tool is called RDFaCE, which is based on WYSIWYM (What-You-See-Is-What-You-Mean) concept (Khalili & Auer, 2013). RDFaCE uses schema.org terms to embed semantic information within the web content. It allows users to choose what
semantic markup format to use to embed schema.org vocabularies with their web contents. Microdata and RDFa Lite are the semantic markup formats that can be used within RDFaCE tool as schema.org currently supports these formats. RDFaCE is implemented on the top of the TinyMCE text editor. It aims to be easily integrated with the existing content management systems (CMSs). It has been integrated to Wordpress (the popular content management system) as a plugin to enable web content to be automatically enriched with semantic information based on schema.org vocabularies in order to test this tool. Wordpress uses TinyMCE as a content editor, which makes it easy to use RDFaCE as plugin with this CMS. However, RDFaCE is still under development; further evaluation and extensions will be performed in order to make it a stable version.

Furthermore, the semantic CMS Drupal has been supporting schema.org despite its current version “Drupal 7” having been launched a few months before the innovation of schema.org in June 2011. They have added microdata and schema.org models to facilitate the embedding of semantic information based on schema.org by using microdata or RDFa formats. Further details about Drupal and its semantic support will be discussed in the next chapter.

2.4.2 Web 2.0 tools

On the other hand, the web 2.0 tools such as social networking and media is another angle in sharing and reusing knowledge and data by increasing the interactivity of learning environments and helping students to collaborate and engage with other learners and educators. Recent research in personalised learning environments with web 2.0 tools is discussed in several research papers.

For example, recent research mentioned the lack of the current Learning Management Systems (LMSs) and VLEs to offer learners social features based on Web 2.0 tools, as the majority of higher education students already interact with these social tools or sites regularly (Sclater, 2008). Therefore, their approach to solve this issue is Personal Learning Environments (PLEs) to interact with other social sites such as wikis, blogs and social networking sites. This research mentioned that there have been some attempts with current open source LMSs such as Moodle to be integrated with social software. For example, MyStuff is developed by the Open University in the UK for Moodle which is based on social software to allow learners to share, discuss, tag and store content with others (Sclater, 2008). Another similar example to the architecture
of MyStuff is Mahara, which is founded by the New Zealand government for Moodle as well. The author also mentioned that some universities encourage students to use social networking by creating academic groups in Facebook (Sclater, 2008).

The use of social media in PLEs is discussed also in this research (Dabbagh & Kitsantas, 2012). Dabbagh and Kitsantas proposed a pedagogical framework of using social media in PLEs to support self-regulated learning. This pedagogical framework consists of three levels: personal information management, social interaction and collaboration, and information aggregation and management. Another self-regulated learning environment that benefits from Web 2.0 services is the Responsive Open Learning Environments (ROLE) project (ROLE project, 2015). It was developed within a collaborative European project that has 16 international research groups from six EU countries and China. The main objective of the ROLE project is to support teachers in developing open PLEs for their students to search for learning resources and plan their learning process independently.

Furthermore, a recent approach to integrating Web 2.0 tools and other technologies into a PLE is introduced in (García-Peñalvo & Conde, 2011). This work proposed a service framework that integrates informal and formal learning environments. This framework has Wookie widgets as the informal PLE environment and Moodle as the formal or institutional environment. The main reason to integrate these two environments together is because institutional or formal learning environment’s (LMSs) resistance against any change regarding the appearance or integrating new technologies such as Web 2.0 tools. Therefore, the authors believe that integrating informal and formal learning environments would solve this problem by integrating new technologies and activities into an informal environment (PLE).

In addition, another theoretical approach goes through the limitations of the traditional VLEs and how these environments can address the learning needs of the future students for a more creative publication platform with web 2.0 development (Craig, 2007). As Craig mentioned, Web 2.0 applications provide different tools and services for learners than they are already familiar with, and can provide also individual resources compared to traditional VLEs or learning content management systems (LCMSs). With the fast growth of the web, Craig stated that the new generation of students would ask for more open, collaborative and responsive learning environments that can be achieved by Web 2.0 services or perhaps other tools and services (2007).
Also, another approach is to support the development of e-Learning ecosystems for more effective Learning Environments based on the use of Web 2.0 technologies and services is discussed in (Gütl & Chang, 2008). Gütl and Chang proposed their approach, “e-Learning ecosystem (ELES) model”, which makes use of a variety of technologies including Web 2.0 technologies (2008). The ELES model basically uses Web 2.0 technologies based on three layers to develop flexible e-learning environments. It can also offer a learning platform for information exchange and communication. The first layer is Web 2.0 technologies, which includes technologies that make Web 2.0 usable such as JavaScript, AJAX, CSS and XHTML. The second layer is Web 2.0 Services and applications such as social networks, media sharing tools, social writing tools and weblogs. The third layer is Web 2.0-based Activities, which include communication, sharing, networking, messaging and collaborative content writing.

In addition, social networking one of the main applications of Web 2.0 tools, has been used in several researches as e-Learning environments instead of LMSs. Recent research on using Facebook as a learning management system is discussed in (Wang, Woo, Quek, Yang, & Liu, 2012). This research used Facebook groups as an LMS for two courses at an educational institute in Singapore to benefit from social networking features such as sharing learning resources, online discussions, announcements and organising weekly tutorials. It is also very easy to implement Facebook groups to play the role of an LMS with free cost comparing to commercial LMSs. Students were satisfied with their experience of using Facebook as an LMS. However, the authors mentioned a few limitations of implementing Facebook as an LMS after their evaluation. For example, they stated that there is a lack of support to upload other file formats directly and discussions are not listed clearly as threads. They also mentioned that students were concerned about the privacy and they do not feel safe. Undergraduate students were more positive than Master students regarding the evaluation of using Facebook as an LMS, indicating that younger people are more accepting of new technologies. The authors have concluded and recommended that Facebook has the potential to work as an LMS although there are some limitations that were mentioned by students as discussed above.

Another recent research called “Socla” uses Facebook as a social learning community for high school students in Japan (Yamauchi, Fujimoto, & Takahashi, 2012). The study is to run a short course for two weeks for high school students in order to test
the experience of students by using Facebook as a social learning community. This study divides students into six small study groups. Each group has a small number of students with adult supporters and facilitators assign to each group to provide assistance for students. The feedback was quite positive from the students regarding their experience with these kinds of short courses. They found that they could get a quick response from their colleagues, supporters or facilitators when faced with any difficulty or problem.

Furthermore, Weber and Rothe have used also the social network service “NING” (a simple social networking service) instead of traditional LMSs to run their courses in a cross-location e-Learning setting, “Net Economy” (Weber & Rothe, 2012). They stated that with the help of the social networking services the connection between students in virtual groups is more transparent. They used NING to create their courses for different university students, which offers them a custom social network with several interactive features including groups, forums, profile pages, status updates, relationships, latest activity streams, announcements, photos and videos. Weber and Rothe conclude that by using social networking services to run courses instead of conventional LMSs, will enhance and facilitate the social presence which will subsequently improve the e-Learning experience for learners.

In addition, a recent report to study the uses of Web 2.0 tools in different scenarios for learning and teaching in Higher Education which was funded by JISC is discussed in (Franklin & Harmelen, 2007). It discussed the uses of Web 2.0 tools including using Blogs, Wikis, Media sharing services and social networking for learning and teaching purposes (Franklin & Harmelen, 2007). This report discussed also some examples of implementing Web 2.0 tools by some universities in the UK which will be discussed below:

**University of Warwick**

The University of Warwick was one of the first educational institutions to offer Web 2.0 services to students and lecturers (Franklin & Harmelen, 2007). It has started to offer personal blogs for all students since 2004. The blog has been used widely according to the statistics that are included in Franklin & Harmelen’s report (2007). Therefore, the university is intending to develop a wiki to be accompany the current blog due to its wide use and success.
**University of Leeds**

The University of Leeds has tried to benefit from the advantages of Web 2.0 services as that fits with their learning and teaching strategy to use the proper technology to enhance learning and teaching (Franklin & Harmelen, 2007). The University of Leeds was one of the first universities to use their own open source VLE, which is called Bodington. In 2005, the university installed Elgg as a blog service and MediaWiki as a wiki that can offer students and staff the ability to share research results, communicate information and work as groups which is part of campus life.

**University of Brighton**

The University of Brighton also started to use Elgg as a blog service in 2006 (Franklin & Harmelen, 2007). It has been integrated with their existing learning system. It has been using as an online social community for students and staff and to share academic interests. This blog is used now formally by staff within modules and courses. Some courses have started to move from Blackboard (the university VLE) to this blog service “Elgg” due to the great communication in the blog. The university believes that this the first steps to move from a VLE to a Shared Learning Environment.

**University of Edinburgh**

The University of Edinburgh is the only university in the UK that has a Web 2.0 strategy with an action plan as the authors stated (Franklin & Harmelen, 2007). The strategy (section 4.4) recommends a greater use of Web 2.0 services with an appropriate infrastructure. This strategy considers that the university can take advantages of using Web 2.0 services including blogs and RSS instead of newsletter, Web 2.0 mapping technology (e.g., Google maps) instead of the university campus maps and other services.

2.5  Analysis the challenges and the research question

2.5.1  Challenges and Potentials

As we have mentioned in section 2.2, there has been relatively little innovation in main stream VLEs in the past few years, which remain heavily centred on single institutions even though the web has been developing (e.g., web 2, web 3). This is due to the stability of their performance working against the development of these learning environments and the introduction of new innovations (García-Peñalvo &
Furthermore, there is no real collaborative work with these environments to help teachers and students with these systems to create a collaborative environment for sharing/reusing data and knowledge as we have with the web in general. It was also mentioned in (Itmazi et al., 2005) about some of limitations (e.g., sharing/reusing learning contents, video services and recommendation system tool) in the top LMSs. Therefore, the sharing and reuse of educational resources is now becoming topical and a main focus in the TEL community in order to address these limitations (Dietze & Sanchez-Alonso, 2013). This points us to the potential benefits to e-Learning from the significant advantages of semantic web technologies as it is used to facilitate reusing and sharing of data on the web as described in section 2.3. As we also mentioned earlier in this chapter, the expectation for the new generation of VLEs is to use the context of semantic web technology in terms of developing e-Learning (Sampson, Lytras & Wagner, 2004). This leads us to the challenges and potentials that we would like to explore in this research. The big challenge and question that is emerging now is, what is the next development step in e-Learning services? We should also ask whether these technologies would really enhance learning? Of course we also need to ask whether we need to make a big change to VLEs? Clearly many people are happy with the current VLEs such as Moodle. In order to answer this question, whilst we know that the current systems attract many people, we also see that there is an emerging demand for more open, collaborative and attractive environments to share knowledge and not only put courses materials online as mentioned in section 2.4.2. Therefore, VLEs should become flexible and open learning environments and not ignore new tools and trends (García-Peñalvo & Conde, 2011).

Our motivation behind the work reported in this research is to support the sharing of knowledge and data in an educational context, and to make VLEs more open, attractive and collaborative for educational and non-educational institutions. Further, we believe that we can increase the attractiveness of these learning systems by linking them to social networks and media. This will also lead to support sharing, reusing and increasing the visibility and discoverability of learning resources. In order to achieve that, we will also use the semantic web to achieve our aims and make a real advance in the state of the art in VLEs. However, our motivation in this research is not only to use new or different technologies and tools to make a big change in e-Learning platforms. On the other hand, our motivation is to benefit from the semantic web...
technology itself and the great advantages of this technology that will reflect on VLEs and enhance learning in general.

Whilst we have seen some ongoing research that uses the semantic web with e-Learning services, this research is focused on using the semantic web to enhance specific features in e-Learning services. Basically, we are focused in this research on the latest developments of semantic web by embedding semantic markup information to demonstration VLE content with the new innovation of schema.org vocabularies. This will impact on this demonstration VLE with several advantages, as it will be described with rich semantic information. Consequently, this will allow course instructors and students to have more accurate and meaningful learning contents when they search within the major search engines. This will also increase the visibility and discoverability of VLEs’ learning content within the big search engines by providing a machine-interpretable semantics to course data.

To our knowledge and also as mentioned in (Bratsas et al., 2012), all the “conventional” virtual learning environments lack enhanced semantic features and support. Instead, the majority of the current applications that do use semantic web technologies apply it to only a relatively small part of VLEs such as authoring, structuring or searching as mentioned in section 2.3. Consequently, a Semantic Content Management System (SCMS) was selected in this research project to deploy and support the development of different parts of e-Learning services for higher education institutes. We aim to prototype a simple VLE using this SCMS that makes use of semantic web technology to add several features and functions to make this VLE a significantly more open, collaborative and attractive environment for teachers and students. After this analysis of the challenges and potentials, this guides us to create our research question.

2.5.2 The research question

This research aims to make a significant development to improve VLEs and give enough power to e-Learning to move to another generation. There is a clear need to integrate VLEs with the wider Web and maintain its learning contents freely open in order to support the sharing and reuse of learning resources. Given also the sharing and reuse of educational content is becoming now a main focus in the TEL community (Dietze & Sanchez-Alonso, 2013). Therefore, this research will investigate that and will use the semantic web technologies to create a simple VLE.
that benefits from the big features of the semantic web. In order to achieve that, we have prototyped a simple VLE that makes use of the Semantic Content Management System (SCMS) Drupal to provide a more open, social and semantic structured learning environment. Essentially, we aim to add semantic markup based on schema.org vocabularies, and integrate social networking and media to develop and enhance VLEs by improving sharing, discovering and reusing of learning contents. This research explores if the semantic web can make a significant distinction and power to e-Learning to influence the next generation of this field and make VLEs more open, collaborative and attractive environments. This research also investigated how we can increase the attractiveness and sharing of content of VLEs by linking to social networks and media to be a freely open environment unlike “conventional” virtual learning environments.
3 A Technology Base for Semantic VLEs

This chapter aims to cover all technologies that are used to implement this demonstration VLE. As mentioned in the previous chapter, this research explored the use of semantic web technology to develop VLEs. This can be implemented by using semantic markup formats (e.g., RDFa, Microformat and Microdata) to add rich semantic descriptions to the web content that can be embedded within the HTML code using standard ontologies or vocabularies. This chapter discusses the major semantic markup formats and focuses more on the syntax that is used in this research. The standard and broad vocabulary “schema.org” is also discussed. This is used to describe the content of the demonstration VLE by embedding its vocabularies within the HTML code using a semantic markup format. After that, we introduce the framework that is used to build this VLE, which is the popular Content Management System (CMS) Drupal after providing a short overview of CMSs.

3.1 Semantic Markup Formats

Nowadays, the web has been developing through the emergence of the semantic web to publish machine-understandable information in the web. We can now create HTML pages with embedded rich semantic metadata in order to publish documents on the web that both machines and humans can understand. This can be implemented by using specific semantic markup formats using standard ontologies, schemas or vocabularies. The three major semantic markup formats for embedding semantic information in HTML documents are: RDFa, microdata and microformat (Adams, 2012).

The major search engines have supported these formats in some fashion in the past few years. For example, Google has been supporting RDFa since 2009 but found a high error rate in its applications over that time by webmasters due the complexity of implementing RDFa (Ronallo, 2012). As a result of this shared experience, the major search engines including Bing, Google, Yahoo! and Yandex agreed in June 2011 to support a particular semantic markup format “microdata” that combines the simplicity of microformat and the extensibility of RDFa (schema.org, 2014a). The specification of the microdata markup format has been created during the development of HTML5 for embedding metadata within HTML code (Adams, 2012).
This section discusses the major semantic markup formats: RDFa, microdata and microformat. It is focused mostly on RDFa, as this research used this specific format to markup the demonstration VLE contents with semantic information. The key reason for choosing RDFa instead of one of the other semantic markup formats was the pragmatic one that the framework “Drupal”, that was used to build this VLE, has a core design built on RDF. There are of course other reasons for selecting this specific syntax, and these are also covered in this section. We will begin by introducing RDF in general to provide a context of the following discussion of RDFa and then discuss briefly the other semantic markup formats Microdata and Microformat.

3.1.1 Resource Description Framework (RDF)

RDF is a language to represent metadata about resources in the web (Sanjaya, 2009). In other words, RDF can be defined as:

"A foundation for processing metadata; it provides interoperability between applications that exchange machine-understandable information on the Web"  
(Nilsson, 2001)

RDF can define the relationship between resources in the World Wide Web. It is not designed to display information to people or to the public facing web but it is designed to provide more information for non-human user agents. RDF provides computers with a clear structure to create relations between resources and look for information (Sanjaya, 2009). It uses URIs to link and name the relationships between these resources. This allows structured and semi-structured information to be combined and shared across many applications and systems. There is an expressive statement that represents the interaction of people through the English language with RDF as a language of communication across applications as follows:

“While English is good for communicating between (English-speaking) humans, RDF is about making machine-processable statements.”  
(Manola and Miller, 2004)

By using RDF statements you can say anything about anything by making RDF statements about any resource in the web. There are important uses of RDF that can encode information for any resource (Nilsson, 2001):

- Describe.
- Certify.
- Annotate.
In order to understand how an RDF statement is displayed, we use a simple example from the W3Schools website to show the syntax of RDF and how can we represent real data by using RDF (W3Schools, 2012).

<table>
<thead>
<tr>
<th>Title</th>
<th>Artist</th>
<th>Country</th>
<th>Company</th>
<th>Price</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hide your heart</td>
<td>Bonnie Tyler</td>
<td>UK</td>
<td>CBS Records</td>
<td>9.90</td>
<td>1988</td>
</tr>
</tbody>
</table>

Table 1: A record of CD list

Table 1 shows a record of specific CD details such as title, price and year. Figure 8 enhances the representation of the data in Table 1 by using RDF meta-data. The first line in this example is the XML declaration, as RDF uses XML as the syntax for this technology. Specifically, XML is a data formatting language, which can be used to define a grammar (syntax) for data (Lacy, 2005). This is followed by the RDF declaration <rdf:RDF>. The xmlns:rdf namespace identifies that the elements with an RDF prefix use terms from the vocabulary defined at "http://www.w3.org/1999/02/22-rdf-syntax-ns#". The xmlns:cd namespace identifies that the elements with a CD prefix use terms from the vocabulary defined at "http://www.recshop.fake/cd#". The <rdf:Description> element specifies that the entities such as <cd:artist>, <cd:country>, <cd:company> are in an “about” relation that describes the resource “Hide your Heart”. The result, Figure 8 is now a machine-readable representation of the data in Table 1.

```xml
<?xml version="1.0"?>
<rdf:RDF
 xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:cd="http://www.recshop.fake/cd#">
  <rdf:Description
    rdf:about="http://www.recshop.fake/cd/Hide your heart">
    <cd:artist>Bonnie Tyler</cd:artist>
    <cd:country>UK</cd:country>
    <cd:company>CBS Records</cd:company>
    <cd:price>9.90</cd:price>
    <cd:year>1988</cd:year>
  </rdf:Description>
</rdf:RDF>
```

Figure 8: An example of RDF syntax of the CD album example (W3Schools, 2012)
3.1.1.1 RDFa

RDFa is an acronym for the Resource Description Framework in attributes. RDFa is an RDF markup format of structured data (Bradley, 2013). It differs from RDF in that instead of marking up with XML, it provides a mechanism for embedding the language of the semantic web “RDF” within an HTML document (Adams, 2012). The RDFa syntax does not change the page content that is displayed by a web browser to a human user. However, it is readable by RDFa-capable software enabling it to interpret the semantic markup of the webpage content (Corlosquet, 2011a). Figure 9 shows an example of how to describe the previous example in Table 1 and Figure 8 in RDFa syntax. Basically, it shows how we embed the previous RDF example in Figure 8 within an HTML document.

```html
<body>
  <div xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
       xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
       xmlns="http://www.w3.org/1999/xhtml"
       xmlns:cd="http://www.recshop.fake/cd#"
       xmlns:xsd="http://www.w3.org/2001/XMLSchema#">
    <div typeof="rdfs:Resource"
         about="http://www.recshop.fake/cd/Hide your heart">
      <div property="cd:artist" content="Bonnie Tyler"/>
      <div property="cd:country" content="UK"/>
      <div property="cd:company" content="CBS Records"/>
      <div property="cd:price" content="9.90"/>
      <div property="cd:year" content="1988"/>
    </div>
  </div>
</body>
```

**Figure 9:** An example of RDFa syntax of the CD album example

In contrast to other semantic markup formats, anyone using RDF/RDFa can create new vocabularies (Adams, 2012). Therefore, RDFa can be freely extended to new vocabularies or using other external vocabularies due to the nature of RDF’s design (Corlosquet, 2011a). However, there are already a large number of RDF vocabularies available as it is widely used and it has a large community. Very recently, a new version of RDFa has appeared called RDFa 1.1, which tries to address some of the concerns around the complexity of RDFa.

As we mentioned above, due to RDFa being widely used and having a large community, it has strong support and interface. RDFa has been a standard for W3C since 2008 (Corlosquet, 2011a). Many high profile companies on the web such as
Facebook, BBC and Google have also adopted it. RDF is considered by many to be the foundation for the vision of the semantic web of Tim Berners-Lee (Nilsson, 2001).

3.1.2 Microdata

Microdata is an HTML5 markup format of structured data (Bradley, 2013). It is a relatively recent development and has been developed during the creation of HTML5 to be part of its specification to embed metadata within HTML code (Corlosquet, 2011a). The Microdata specification avoids some of the concerns around the limited vocabularies of Microformat (see below) and the complexity of RDFa. Microdata shares more characteristics with RDFa than microformats, such as extensibility (Corlosquet, 2011a). It consists of a group (called items) of name-value pairs (each pair called a property) (Hickson, 2013).

Support for Microdata received a major boost in June 2011, as Bing, Google, Yahoo! and Yandex announced the new innovation of schema.org and stated a preference to use the Microdata markup syntax (Adams, 2012). Microdata is the first primary method used to embed schema.org information into web content (Bradley, 2013). The big search engines have explained their choice of using Microdata instead of other markup formats due to its balance between the simplicity of Microformats and the extensibility of RDFa (schema.org, 2014a). An example of using Microdata syntax with the specifications of schema.org vocabulary for the CD records example in Table 1 will be presented in schema.org section (section 3.2).

3.1.3 Microformat

Microformat is another markup syntax and has a collection of vocabularies (hCard, vCard, etc.) (Bradley, 2013). It is a lightweight and simple semantic markup format to embed semantic annotation about a specific domain (Adams, 2012). Microformat was the first markup format that has been used widely by the web developer community (Corlosquet, 2011a). The specification of Microformat has broad data types that have already seen widespread usage. For example, the hCard data type is used to describe people and organisations. Microformats have been designed to be very simple for webmasters to markup their webpages with the widely used HTML features. However, it is a difficult process to create a new data type in Microformat and was never standardized due to its limited development of vocabularies, due to its a lack of its extensibility (Corlosquet, 2011a). Furthermore, Microformat does not have a
formal extension mechanism for creating ad hoc extensions as in schema.org and other popular semantic markup formats (Bradley, 2013).

3.2 Schema.org

In June 2011, the major search engines (Bing, Google, Yahoo! and Yandex) announced the new innovation of schema.org. schema.org is a joint effort by Google, Microsoft, and Yahoo! to create a structured data markup schema supported by major search engines in order to improve the web content meaning (Google Webmaster Tools, 2014). It has broad and supported vocabularies that can be understood by the major search engines. The big search engines have agreed to support and understand it. schema.org is currently available in English only but there is a plan to translate it to other languages in the future.

The main goal behind creating schema.org is for it to be a single place for webmasters, with broad syntax and style consistency across types (schema.org, 2014a). Therefore, webmasters need to be familiar with only one vocabulary rather than having to learn and understand different, possibly overlapping vocabularies. However, most vocabularies on schema.org were inspired by other earlier work such as FOAF, Microformats, OpenCyc, etc (schema.org, 2014a). This is a really pragmatic decision from the major search engines to have a unique, web-scale and broad vocabulary that is supported by them, as it is unrealistic to support every vocabulary or ontology in use (Ronallo, 2012). This is the key reason for choosing schema.org in this research instead of other schemas and vocabularies due to the support from the major search engines. Furthermore, schema.org can be described as a “middle ontology” focusing on popular concepts (Ronallo, 2012). It uses HTML5 elements to embed semantic markup within the webpage html code.

schema.org has a hierarchy of types that all inherit from the root class “Thing” which has specific popular properties such as description, image, name and url. All other types inherit these properties and they also have their own properties. CreativeWork, Event, Product, Person, Place, Organization and Property are the popular child types of the root type “Thing”. These types have other specific child types with their own properties that inherit also from their parent types. Furthermore, all these sub types have also other child types that have very specific focus, as schema.org is a broad vocabulary that covers most the terms, which can be needed to describe the web contents. For example, the expressive type
“CreativeWork” has many child types such as Article, Blog, Comment and Book to put CreativeWork in Article, Blog, Comment and Book contexts. Figure 10 shows how a specific type’s hierarchy (e.g., MusicAlbum) appears in the schema.org site. Figure 11 shows also how we describe the previous example in Table 1 using schema.org vocabularies and Microdata syntax. Basically, we use this specific type “MusicAlbum” in order to describe the CD album records in Table 1.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>byArtist</td>
<td>MusicGroup</td>
<td>The artist that performed this album or recording.</td>
</tr>
<tr>
<td>sumTracks</td>
<td>integer</td>
<td>The number of tracks in this album or playlist.</td>
</tr>
<tr>
<td>track</td>
<td>MusicRecording</td>
<td>A music recording (track)—usually a single song. Supercodes tracks.</td>
</tr>
</tbody>
</table>

**Figure 10:** The hierarchy of MusicAlbum type in schema.org

```html
<div itemscope itemtype="http://schema.org/MusicAlbum">
  <span itemprop="name">Hide your heart</span>
  <div itemprop="byArtist" itemscope itemtype="http://schema.org/MusicGroup">
    <span itemprop="name">Bonnie Tyler</span>
  </div>
  <div itemprop="contentLocation" itemscope itemtype="http://schema.org/Place">
    <span itemprop="name">UK</span>
  </div>
  <div itemprop="copyrightHolder" itemscope itemtype="http://schema.org/Organization">
    <span itemprop="name">CBS Records</span>
  </div>
  <div itemprop="offers" itemscope itemtype="http://schema.org/Offer">
    <span itemprop="price">9.90</span>
  </div>
  <meta itemprop="datePublished" content="1988">
</div>
```

**Figure 11:** An example of Microdata syntax and schema.org of the CD album example
In addition, the major search engines are currently the main consumers of schema.org vocabularies. They have also stated a preference to use microdata format with schema.org (schema.org, 2014a). The reason behind supporting this specific format instead of other popular formats such as RDFa and Microformat is due to search engines want to support a single syntax to improve consistency across search engines and avoid the complexity of documentation for multiple syntaxes for webmasters (Google Webmaster Tools, 2014). Furthermore, another reason of supporting only Microdata is due to the limitations of other formats. For example, Microformats do not offer open extensibility mechanisms to extend vocabularies as mentioned in the past section (schema.org, 2014a). Also, RDFa suffers by the complexity of its syntax when used by webmasters (schema.org, 2014a).

Very recently, schema.org has started to support RDFa 1.1, in particular RDFa Lite 1.1 version, additionally to its preference for the microdata format after the emergence of this version of RDFa as it has the simplicity of microdata and the high demand from the community (schema.org, 2013). This is a very important direction to this research, as it uses the semantic content management system Drupal 7 to implement our demonstration VLE, and its core design is built on the Resource Description Framework (RDF).

In addition, Search engines are using schema.org markup in a variety of ways. It helps search engines to provide more accurate results and return more meaningful information. It will also help search engines to display rich snippets in search results by highlighting the most important information as discussed in section 2.4.1.4 in the past chapter with some existing examples. Currently, Google only supports rich snippets for the following types in schema.org: People; Products; Events; Authors; Applications; Movies; Music; Recipes; Reviews; TV series (Ronallo, 2012). Furthermore, the importance and success of schema.org is clearly visible now, as it has been used widely in many applications and research projects in the past few years as discussed in section 2.4.1.

However, there is a lack of VLE vocabulary’s support in schema.org to describe VLEs or online course content with rich semantic data due to schema.org being a new innovation and still evolving. schema.org offers the ability to extend the current schema and welcomes the receipt of new proposals from the community by specifying additional sub-types or properties to existing vocabularies (schema.org, 2014b). A very recent support to describe educational resources with rich semantic
data has been proposed by the Learning Resource Metadata Initiative (LRMI), which was just added officially to schema.org in April 2013 (LRMI, 2015).

3.2.1 LRMI Specification

The Learning Resource Metadata Initiative (LRMI) aims to make it simpler to deliver, discover, and publish quality-learning materials on the web with the confidence that the big search engines will understand and support this metadata (LRMI, 2015). Basically, they have included eight new properties to the expressive type schema.org/CreativeWork: educationalUse, typicalAgeRange, timeRequired, educationalAlignment, interactivityType, useRightsUrl, isBasedOnUrl and learningResourceType. There are also other important characteristics, which can be used to describe learning resources that are already covered by schema.org in the expressive type CreativeWork such as author, publisher, inLanguage, dateCreated and about. They have also created two new types/classes with their own properties to the existing schema: schema.org/AlignmentObject and schema.org/EducationalAudience. Figure 12 shows the hierarchy of these two new types in schema.org site and their new properties.

Of course, VLEs and other online courses such as “Massive Open Online Courses (MOOCs)” will benefit from these learning resources metadata that have included to the schema very recently by LRMI. On the other hand, there is still a lack of learning content terms to cover all VLE’s structured vocabularies and hierarchies, such as courses, sessions/lectures and assignments with other specific properties even after the recent support by LRMI. After this overview of schema.org, we will discuss now the framework that we are going to use to deploy our demonstration VLE and the move towards Semantic CMS in the next section.
Figure 12: The hierarchy of AlignmentObject and EducationalAudience in schema.org

3.3 Content Management Systems (CMSs)

A Content Management System (CMS) is software that provides a collection of procedures, which can create and manage the work in a collaborative environment (Mauthe & Thomas, 2004). It can manage a large collection of web material such as HTML contents and documents. CMSs can categories into free open source CMS and commercial (also known as enterprise or proprietary) CMS (Mauthe & Thomas, 2004). There are many CMSs examples whether commercial or free open source CMSs. Expression Engine and SharePoint are among the most popular examples for commercial CMSs. On the other hand, Drupal, WordPress and Joomla are considered the largest and most popular free open source CMSs (Corlosquet, Delbru, & Clark, 2009).
The main difference between the commercial and free open source CMSs is the software in commercial CMSs is owned by CMS Companies and the code cannot be accessed. On the other hand, free open source CMSs are non-profit software that promote the freedom of computer users to study, share and modify the code; and to allocate the rights to all free software users (FSF, 2012). They have a group of developers who work in a collaborative environment. They work as volunteers to add features or new functionality, fix problems or bugs and check for security updates. Thereby, there is 3rd party help in this type of CMS if you look for best support and documentation as the support can be obtained from a large community of volunteer developers.

In addition, the commercial CMSs have a big limitation, which is the support team comes from only one point as the software is owned by a company. As a result, adding a new feature or fixing any problem can take a while depending on the priorities of the support team. In contrast, the free CMSs have thousands of developers that can foster the support although they are volunteers. Furthermore, free CMSs have a big advantage, which allows users to access the code at any time.

Recently, a new generation of CMS is appearing called Semantic Content Management Systems (SCMS) (Bratsas et al., 2012). These are similar to the conventional CMSs but have advanced support for semantic features. Currently only Drupal among the most popular CMSs has advanced support for semantic features built into the core of its latest version (Bratsas et al., 2012). Thereby, it can create a bridge between CMS and Semantic Web technology (Corlosquet, Cyganiak, et al., 2009). Therefore, we have chosen Drupal framework to build our semantic VLE. Further detail about the move towards Semantic learning management system (SLMS) is discussed after describing the Drupal architecture in the following section.

### 3.3.1 Drupal

Drupal is an open source software package that allows anyone to easily publish, manage and organise a wide variety of content on a website (Drupal, 2015). It has been developed by a community of thousands of users and developers. In addition, it is a large CMS (Content Management System), blogging tool, forum, and social networking application (Drupal, 2015). Furthermore, it can be also described as a Content Management Framework (CMF) not just CMS. Furthermore, the CMF shares aspects of CMS and Web Application Framework.
Drupal is a framework for quickly building all kinds of powerful web applications. The site administrator initially sets up a site by installing the core Drupal Web application and chooses from a large collection of modules (Corlosquet, Delbru, et al., 2009). Therefore, site administrators need a fair bit of technical knowledge to choose and configure modules, but usually do not write code as module developers focus on this instead (Corlosquet, Cyganiak, Polleres, & Decker, 2009). In addition, Drupal facilitates the creation of websites by handling many aspects of site maintenance, such as data workflow, access control, user accounts, and the encoding and storage of data in the database (Corlosquet, Cyganiak, et al., 2009).

As Figure 13 shown, Drupal consists of five main layers. First, the base of this architecture is a collection of nodes, which holds structured information such as title, author and body text (Krause, 2011). Second, modules which mean adding functionality to the system that have many options such as to generate reports and create forms or questionnaires. Next, blocks that mean the output of modules that can be configured to show whatever you want. For instance, it can be configured to certain pages or users such as user login (Krause, 2011). After that, the fourth layer that is user permissions that means what you can see and do based on the permission that you have. Finally, the top layer is the template layer or can be called site themes (the “skin”). After this overview of the Drupal framework, the next section justifies
our selection of Drupal and the move towards Semantic learning management system (SLMS).

3.3.2 Moving towards an expressive LMS

We have chosen Drupal as the framework for building our demonstration VLE for many reasons. First, Drupal is considered one of the top three open-source CMS products (Drupal, WordPress and Joomla) in terms of market share (Corlosquet, Delbru, et al., 2009). Second, we have chosen Drupal in preference to the other similar competitors, as we require a lot of customisations in our demonstration VLE and Drupal is a good solution for that purpose. We take also into account that some other CMSs (e.g. WordPress and Joomla) or LMSs (e.g. Moodle) are easier for users and Drupal configuration sometimes needs some coding, which means Drupal’s user needs some background in programming. Furthermore, Drupal has a core performance, speed and memory usage that compares well with similar competitors. As mentioned above, the key reason to choose Drupal instead of other CMSs or LMSs is because it can support Semantic Web technologies. Drupal has implemented a module for that purpose which called Drupal’s CCK (Drupal’s Content Construction Kit) with the ability to auto-generate RDF classes and properties for all content types and fields. To summaries the main features of this semantic module (RDF CCK) are that it: (Corlosquet, Delbru, et al., 2009)

- Adheres to Linked Data principles.
- Maps to Existing Ontologies.
- Provides an external vocabulary importer service.
- Provides an external ontology search service.
- Provides a mapping process.

Furthermore, RDF CCK is available at the official Drupal site. It allows linking newly deployed Drupal and existing sites to the Web of Data by a few steps and clicks (Corlosquet, Delbru, et al., 2009). It allows the site administrator to define types of nodes, called content types, and to define fields (e.g. plain text fields, email addresses, or dates) for each content type (Corlosquet, Cyganiak, et al., 2009).
Recently, Drupal has released a new version (Drupal 7 core) with RDF support built in, without requiring any additional module such as RDF CCK as in the past version, which will result in improved performance of the system (Corlosquet, 2011b). Figure 14 shows the default RDF mappings support as defined in Drupal 7 based on the major vocabularies (FOAF, SIOC, SKOS and DC).

![Diagram of Drupal 7 default RDF mappings support](image)

**Figure 14: Drupal 7 default RDF mappings support**  
(Corlosquet, 2011a)

The functionality in this new version of Drupal is extended with a high speed that supports RDF by default. For example, the popular default content types such as Article and Basic Page are exposed automatically by default with RDF mappings with their relevant vocabularies and terms as described in Figure 14 (Clark, 2011a). Further, Drupal is the first major CMS that integrates a full support for semantic web technologies in its latest version Drupal 7 which was launched in January 2011 (Havlik, 2011).
Very recently, after the emergence of schema.org in June 2011, few months after the release of the current version (Drupal 7), the Drupal community started to work to support for this broad and global schema due to the support from the major search engines and the high demand from the community. Therefore, a Microdata module has been launched only a few months after the emergence of schema.org. It replaces RDFa syntax with microdata as schema.org initially supports only this syntax. A further detail about the use of this module with some examples in Drupal 7 is discussed in (Clark, 2011b). After the very recent support of the latest version of RDFa by schema.org as mentioned in the past section, Drupal launched a module called schema.org that helps to markup webpages with schema.org vocabularies based on RDFa, the default semantic markup syntax in Drupal 7. Therefore, we will use this module (schema.org) to markup our demonstration VLE contents based on schema.org vocabularies instead of Microdata module due to it being stable and the high number of users of this module compared with the Microdata module. The schema.org module is also used as the default semantic syntax RDFa in Drupal 7 to markup the web content based on schema.org vocabularies.

In addition, schema.org support in Drupal is promised to be the default vocabulary in the next version (Drupal 8). Drupal 8 aims to replace most of the terms from the vocabularies (FOAF, SIOC, SKOS and DC) that are used in the current version (Drupal 7) with their equivalent terms from schema.org (Corlosquet, 2013). This is due to the great success and popularity of schema.org in the past few years. Further, the support from the major search engines for schema.org vocabularies is a key factor of that important decision. Figure 15 shows the proposed default RDF mappings support as defined in Drupal 8 based on schema.org vocabularies.

Finally, this makes us confident to work with Drupal as it has a large community that works to make Drupal a vital part of the semantic web by adding structured data to the web (Corlosquet, 2011b). Drupal’s community is a very active community to make Drupal work with the state of the art of semantic web technologies development as we have seen in this section. Drupal can, of course, be used to create systems and web sites for educational use and can play the role of a Learning Management System (LMS) (Bratsas et al., 2012). It can expose the learning content to the web of data with rich semantic data. Basically, Drupal will help us to describe this demonstration VLE contents with semantic information based on schema.org vocabularies and using RDFa syntax to embed this semantic information within the VLE webpages. It is for
these reasons that Drupal was selected to be the SLMS to implement and deploy our demonstration VLE. The specification and architecture of this demonstration VLE is discussed in the next chapter.

Figure 15: The proposed default RDF mappings based on schema.org in Drupal 8
(Corlosquet, 2013)
4 VLE Architecture

This chapter discusses the core design of our VLE architecture in depth. First, it will discuss the simple data model structure diagram of this prototyped VLE and the process of creating a course including creating sessions, assignments and forums. Second, it will describe the content types with the related fields that were already mentioned in the data model diagram. After that, the specification of this demonstration VLE will be described with its core features and functions. Finally, this chapter ends with a discussion of the integration of this VLE with social networking and media-enhanced features.

4.1 Data Model

This prototype VLE is a simple learning platform that has the basic functions of other conventional VLEs. We have tried to keep the design of this VLE as simple as we can in order to facilitate integrating and testing new technologies and functions to this demonstration platform in order to explore how they are useful and applicable to be used within VLEs. This section is discussed the high level design of this prototyped system. This demonstration VLE consists of four main classes/types: Course; Session; Assignment; and, Forum. Figure 16 shows a simple data model diagram of this VLE. This diagram shows these classes with their related fields and the relationships between these classes.

As Figure 16 shows, Course could have several sessions or lectures in this VLE as in general the basic design of courses is to consist of several sessions. This context can be applied also on Assignment and Forum and their relationships to Course. Further, Assignment can be assigned either to a specific course or a related session. In addition, Forum is not restricted to be assigned to a course only; it can be linked to a session or an assignment. In order to present a clear picture of this simple data model, the process of creating courses including creating sessions, assignments and forums in this demonstration VLE is discussed after this diagram below.
4.1.1 Course Creation Process

In order to create a course in this VLE, the course instructor should go through several processes. First, we start from the Course class to identify some important fields such as the course name, subject (e.g., computer science), unit (e.g., programming), short description about the course, the start date of the course and support materials by adding external links to these resources. After completing all these fields, the course can be created and will appear on the system. After that, the course instructor is able now to create sessions, assignments and forums for this course.

In order to create a session, the course instructor should specify some important fields such as the title of this session, the presentation date, a short description about this session, lecture content (e.g., outline or agenda of this session), any file of this session such as presentation handouts, any external resource that could support this session and media. For the media, the course instructor can add recorded videos or audios about the session or any related media. After that, the session can be assigned to a specific course.
In addition, to add any assignment to this course, the course instructor should fill a number of fields such as the title of this assignment; deadline; short description about this assignment; the content; and, any file can be attached to this assignment. After that, the assignment can be linked to a related session or to a whole course. Finally, students and lecturers can create posts in the forum. In order to create a forum, students or lecturers should type the title of this forum, subject, discussions and the body of this discussion. Each forum can be linked to a whole course, an assignment or a session. We have shown this simple structure of this VLE’s data model in order to understand it before representing it with rich semantic markup data based on schema.org vocabularies and integrating it to social networking and media, which will be discussed in the upcoming sections. Next, the content types that are mentioned in the data model diagram will be described, explaining the purpose of each type and its related fields.

4.2 Content Types

As this VLE is built on the core of Drupal 7, there are different content types that are available in the core design of Drupal such as Article and Basic page. In order to build this VLE in Drupal, we should create new customised content types that are applicable to the VLE’s structure. As mentioned in the previous chapter, Drupal can offers a lot of customisations to developers and users. Therefore, we require specific content types that are relevant to structure the VLE’s content such as Course and Session in order to build our demonstration VLE in this framework. Consequently, we have created new content types, as mentioned in the previous section in the data model diagram: Course, Session, Assignment and Forum. In addition, we used the existing content type “Article” to create the home page of this VLE. This available content type has the following fields: title, body and image. These few fields in this content type are enough to publish the home page of this prototyped VLE. However, this available content type is not fixed on these fields and can be modified to have additional fields, as Drupal is a flexible and customisable framework. We will discuss below the new content types that have been created specifically for this demonstration platform in order to have a solid structure of this learning environment. The specification of the new content types is described below including their new fields, expected types and a short description of each field.
4.2.1 Course

Course is the root class/content type in this VLE, which can be used to create new courses. It consists of 13 new fields to cover most information that can be used to publish course content on the web. However, it is not necessary to use all these fields in order to create course content as each course material is different compared with other courses. We have tried to maintain the fields’ titles as clearly as possible in order to help structure these fields with rich semantic information, which will be discussed in the next chapter in detail. Table 2 shows this new content type “Course” with its new fields, expected types and short descriptions about each field.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Text</td>
<td>The title of the course.</td>
</tr>
<tr>
<td>Description</td>
<td>Long Text</td>
<td>A short description of the course.</td>
</tr>
<tr>
<td>Course Date</td>
<td>Date</td>
<td>The start date of the course.</td>
</tr>
<tr>
<td>Course End Date</td>
<td>Date</td>
<td>The end date of the course.</td>
</tr>
<tr>
<td>Subject</td>
<td>Text</td>
<td>The subject or the field of the course; for example, ‘Software Engineering’.</td>
</tr>
<tr>
<td>Unit</td>
<td>Text</td>
<td>The specific field of the course; for example, ‘Programming’.</td>
</tr>
<tr>
<td>Provider</td>
<td>Text</td>
<td>The provider that distributed the course.</td>
</tr>
<tr>
<td>Genre</td>
<td>Text</td>
<td>Genre of the course.</td>
</tr>
<tr>
<td>Typical Age Range</td>
<td>Text</td>
<td>The typical range of ages for the contents, for example ‘7-12’.</td>
</tr>
<tr>
<td>Language</td>
<td>Text</td>
<td>The language of the content.</td>
</tr>
<tr>
<td>Course Instructor</td>
<td>Text</td>
<td>The author of the course.</td>
</tr>
<tr>
<td>Image</td>
<td>Image</td>
<td>The course image or logo.</td>
</tr>
<tr>
<td>Support materials</td>
<td>File</td>
<td>The support materials of the course.</td>
</tr>
</tbody>
</table>

Table 2: Course content type fields

4.2.2 Session

Session is the second content type, which can be used to create sessions in this VLE. It consists of 12 new fields in order to cover most session information that can be used to publish session contents. It is not mandatory to use all these fields in all sessions, as each session requires different content. Table 3 shows this new content type “Session” with its new fields, expected types and short descriptions about each field. The last field in this table is “Course” which can be used as citation to the root course of this session or lecture.
### Table 3: Session content type fields

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Text</td>
<td>The title of the session.</td>
</tr>
<tr>
<td>Summary</td>
<td>Long Text</td>
<td>A short summary of the session.</td>
</tr>
<tr>
<td>Presentation Date</td>
<td>Date</td>
<td>The Presentation Date of the session.</td>
</tr>
<tr>
<td>Lecture Content</td>
<td>Long Text</td>
<td>Headline of the session or lecture.</td>
</tr>
<tr>
<td>Media</td>
<td>File</td>
<td>An embedded video object; For example, 'screencasts of the session'.</td>
</tr>
<tr>
<td>Copyright Holder</td>
<td>Text</td>
<td>The party holding the legal copyright.</td>
</tr>
<tr>
<td>Lecturer</td>
<td>Text</td>
<td>The author of the lecture.</td>
</tr>
<tr>
<td>Image</td>
<td>Image</td>
<td>The session image.</td>
</tr>
<tr>
<td>Time Required</td>
<td>Text</td>
<td>Approximate or typical time it takes to work with or through this learning resource.</td>
</tr>
<tr>
<td>Lecture Files</td>
<td>File</td>
<td>The files of the session such as lecture handout.</td>
</tr>
<tr>
<td>External Resource</td>
<td>Link</td>
<td>External resources of the session such as additional tutorial.</td>
</tr>
<tr>
<td>Course</td>
<td>Node reference</td>
<td>A citation to the name of the course.</td>
</tr>
</tbody>
</table>

### 4.2.3 Assignment

Assignment is the third content type, which can be used to create assignments in this prototyped VLE. It consists of seven new fields in order to cover most assignment contents that can be used to publish assignment information on the web. It is not necessary to use all these fields in all new assignments, as each assignment requires different content. Table 4 shows this new content type “Assignment” with its new fields, expected types and short descriptions about each field. The last two fields in this table are “Course” and “Session” which are used as citation or reference to the relevant course or session of this assignment. Meanwhile, as mentioned above in the data model diagram, an assignment can be assigned to either a course as a whole, or to a relevant session in this VLE.

### Table 4: Assignment content type fields

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Text</td>
<td>The title of the assignment.</td>
</tr>
<tr>
<td>Content</td>
<td>Long Text</td>
<td>A short description of the assignment.</td>
</tr>
<tr>
<td>Deadline</td>
<td>Date</td>
<td>The deadline for the assignment.</td>
</tr>
<tr>
<td>File</td>
<td>File</td>
<td>Any resource or file of the assignment.</td>
</tr>
<tr>
<td>Educational Use</td>
<td>Text</td>
<td>The purpose of a work in the context of education; for example, 'assignment'.</td>
</tr>
<tr>
<td>Course</td>
<td>Node reference</td>
<td>A citation to the name of the course.</td>
</tr>
<tr>
<td>Session</td>
<td>Node reference</td>
<td>A citation to the name of the session if applicable.</td>
</tr>
</tbody>
</table>
4.2.4 Forum

Forum is the fourth and last content type in this VLE, which can be used to create forums. It consists of five related fields to cover all forum contents that can be used to publish forum information. It is mandatory to use all these fields in all forums in order to publish this content type. However, this content type is not completely new like the previous three content types, as they have been created from scratch in this platform. We used the available module “Forum” in Drupal 7 projects, in order to create this content type “Forum”. Table 5 shows this content type “Forum” with its fields, expected types and short descriptions about each field. A forum can be assigned to a course, relevant session or an assignment in this VLE, as mentioned in the data model diagram in the past section.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>Text</td>
<td>The title of the forum.</td>
</tr>
<tr>
<td>Body</td>
<td>Long Text</td>
<td>The description of the forum.</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
<td>The forum published Date.</td>
</tr>
<tr>
<td>User</td>
<td>Person</td>
<td>The user who published the forum.</td>
</tr>
<tr>
<td>Forums</td>
<td>Term reference</td>
<td>A reference of the forum to the relevant course.</td>
</tr>
</tbody>
</table>

Table 5: Forum content type fields

After this general overview of the basic architecture of this prototyped VLE, the next section is discussed the specifications of this VLE including the new features and functions that have been integrating to this learning platform.

4.3 VLE Specification

This section gives an overview of the specification of this demonstration VLE. A further detail about each feature is described in the upcoming sections. As mentioned earlier, the reason behind creating this simple VLE is to implement these functions and technologies which will be discussed briefly in this section and investigate how they are useful to be integrated within VLEs. Figure 17 summarises the novel features of this prototyped VLE.

As this figure shows, we prototyped a simple VLE that makes use of the Semantic Content Management System (SCMS) Drupal to provide a more open, social and semantic structured learning environment. Essentially, this VLE aims to add semantic markup based on schema.org vocabularies, and integrate social networking and media to develop and enhance VLEs by improving sharing, discovering and reusing of
learning contents. As mentioned in the previous chapter, the aim of this research is not only integrating new technologies and tools to VLEs, but to benefit from the latest technology in the web to enhance these learning systems and learning in general, and move these environments to a new generation of development.

![VLE Diagram]

Figure 17: An overview of VLE specifications

In addition, Figure 17 lists the most important functions and features of this demonstration VLE. The first feature of this platform is to be an open learning environment unlike the conventional VLEs as they store their learning contents in closed environments. Meanwhile, this VLE content is intended to be freely available on the web in order to ensure its learning contents are accessible to all search engines and web users. Further, this VLE content layout has a simple design in order to maintain its contents to be easily reached and attractive in the same time. A further detail about enhancing content layouts is discussed in the following sub section with some real screenshots of the existing content layouts of this VLE.

Furthermore, this VLE has been integrated into social networking and media. This allows learning materials to be shared with friends and relatives, as this VLE is an
open environment. This can of course support the sharing of knowledge with others in the web. This VLE also supports all sort of media such as videos, screencasts and audios. It has also some enhanced-media features such as video annotation and section or chapter tags in order to enhance the media support for the purpose of learning. Further details of supporting social networking and media-enhanced features are discussed in the next section.

Finally, the long and main task of this PhD project is to integrate this VLE with semantic web technologies. Basically, this VLE aims to embed rich semantic markup information based on schema.org vocabularies within the web content of this system using the semantic CMS “Drupal”, as it has advanced semantic web support which helps to complete this task. Further details of this important task are discussed in the next chapter.

4.3.1 Content Layout

The content layout of this VLE has been designed to facilitate the reach and attractiveness of learning content. This VLE’s content layouts also tends to overcome the lack of the content layouts in the conventional VLEs as their learning contents are stored in closed folders unlike the current web contents. Furthermore, the basic design of the content layouts of this system is to store its contents as “blogs” like the form of web contents nowadays as Figure 18 shows. This figure shows the layout of the home page content in this demonstration VLE.

![Figure 18: The layout of the home page content](image-url)
This works with what we have seen in the previous chapters in section 2.4.2, as university of Brighton uses “Elgg” formally as a blog service (Web 2.0 tool) by staff within modules and courses. They found that some courses have started to move from the official university VLE due to the success of structuring courses content within blogs and the great communication in the blog. Therefore, this encourages us to publish this VLE content as “blogs”. This allows to structure learning contents in a simple way and facilitates the sharing of learning resources. Furthermore, it makes it simple to describe learning content with semantic information compared with storing learning materials within closed folders. Figures 19 and 20 show the structure of course and session layouts.

A blog also has a good interaction with users, as it is a Web 2.0 tool, which can be used, of course, with learning contents and resources. In this VLE, this interaction is by posting comments by learners or lecturers under any page and all sorts of content types in this system (Course, Session, Assignment). This makes this learning system a social site because of this interaction between users in this VLE’s pages. However, it is the course instructor’s choice to enable or disable this interaction with learners by posting comments in a course or a session page.

Figure 19: The layout of a course content in this VLE
In addition, as mentioned earlier in this chapter, there is a forum facility in this VLE, which can be used to post general enquiries. It can be used also in case the course instructor has disabled the comments facility in course, session and assignment pages. Meanwhile, forum can be then assigned directly to these content types. Figure 21 shows the layout of a forum content in this demonstration VLE. Furthermore, lecturers and students can use the facility of a WYSIWYG (What You Say is What You Get) text editor to post any comment in this VLE as Figure 21 shows. The WYSIWYG text editor facility is available also for course instructors to create all sorts of content in this demonstration VLE.
4.4 Role of Social Networks and Media

As this prototyped VLE is a social learning platform, it has been integrating with the social web to provide a more open and social learning environment. This task aims to discuss the linking of this social VLE with social networking sites. This task aims also to support media with additional enhanced-media features. This will help to develop and enhance VLEs, specifically this prototyped VLE, by improving the sharing, discovering and reusing of learning contents. The linking of this VLE with social networking and the support of media will also make this VLE more attractive and communicative. Further details about the social features in this demonstration VLE are described in this section. The sharing of content with social networking is discussed first and then we move to the support of media with its enhanced features.

4.4.1 Sharing of Content with Social Networking

As mentioned in chapter 2, the new generation of students would ask for more open, collaborative and responsive learning environments in order to learn and interact with a high level of social and creative engagement (Craig, 2007). Consequently, we have
added several social features to this prototyped VLE. All the following features in this section have already been added to the system and are working well. We ran a trial version of this VLE in the autumn semester 2013/2014, in order to test the system and elicit feedback from students during the development of this platform. This feedback helped us to test and evaluate the social functions and explore if this VLE meets our aim to improve VLEs to be more communicative and social. We have tried to maintain the design of this VLE with its contents as simple html page “blogs” to be easier for sharing content and user friendly, in contrast to most conventional VLEs where the contents are stored in folders. The main social features that have been integrating to this prototyped VLE are discussed below.

4.4.1.1 Linking with social networks

The first social function in this VLE is to link it with other popular social networks to emphasise its social nature above its functionality as a learning system for only uploading and downloading course materials. This linking allows students to share any learning content including course, session and assignment materials within this VLE to their peers in social networking. Meanwhile, learners can share learning resources or specific lecture slides to their friends within social networking. They can also share their questions on the discussion forum with their friends and former students on social network sites (e.g., Facebook, Tweeter, Google +, LinkedIn or any other social networks from the share button). They can also help each other and specify problems in large networked environments. Former students of a module are able to share their knowledge and learning materials with current students. Figure 22 is an example of how this VLE’s contents can be shared within social networking. Basically, the figure below shows how lecture content in this demonstration VLE can be shared in Facebook. This task benefits from using a “ShareThis” module that is available in Drupal in order to support the link of this VLE with other popular social networking sites. This is the advantage of working with an open source environment to benefit from other people/developer’s work. Given that Drupal has a very large community who work together to ensure this customizable CMS tracks the state of art of web technology development.
In addition, this allows keeping students and lecturers up to date with their education environment and with their social networks. This will allow one form of sharing knowledge on the web. Therefore, the significant advantage of sharing contents with social networking sites is to make learning resources available to more people/learners (Brown & Adler, 2008). Basically, students are able to re-producing the learning contents to other social sites unlike the conventional VLEs where the content is produced restricted only by the courseware. Thus, if more people/learners use these learning resources, more information is shared and the more useful they become (Downes, 2005).

### 4.4.1.2 Importing user profiles from social networks

Another function of linking our VLE with social networks is to import the user profile from other social networks to this system. This will facilitate the registration process of this demonstration VLE with only one click. Some social networking sites support the semantic web by making their users’ profiles available. Facebook, Flicker and Twitter all support semantic web by making their users profiles available in RDF or they allow turning their data by using specific wrappers to convert the data from these systems into RDF format (Bojars, Breslin, & Decker, 2008). This then can support the sharing of user profiles between this prototyped VLE and social networking sites. Figure 23 shows how the importing of user’s profile information is displayed in our VLE. This
user’s profile information was imported from Facebook as displayed below. The user’s profile information is displayed in JavaScript Object Notation (JSON) format, as Facebook displays profile information in this format. The user’s profile information is only displayed to the administrators of this VLE.

![Image of user profile information]

**Figure 23: The importing of user’s profile information**

The user profile contains the basic information about the user. The user profile photo will also be imported from the social network to appear within the discussion forum as a social discussion as shown in Figure 21 in the past section. In addition, this feature will benefit from using the user login details from the user profile to login to this prototyped VLE. Basically, the user can login to the system by clicking on the “Connect” button, which will ask the user about the username and password of the social network. The system is also able to associate the original user account with the social network account by using the user email as ID. Consequently, the user of this VLE may for the next visits use either the social login or the conventional login details to access the system and identify the user. Figure 24 shows the two login options that
are displayed to the users; whether the user wish to create a new account or using an existing account with Facebook.

![Login options in the home page](image)

Figure 24: Login options in the home page

However, the users should be a little cautious of sharing their profiles information in this learning environment from social networks. Currently, this function is only available in this VLE for Facebook users given its popularity and the fact that it allows data to be available for users over the Facebook open graph, which is the use of semantic web from Facebook. This task benefits from using the “Drupal for Facebook” module that is available in Drupal in order to support the importing of user profile information from Facebook to this prototyped VLE.

### 4.4.2 Enhanced-Media Features

This demonstration VLE offers media support with additional enhanced-media features, which is currently missing in most conventional VLEs. In contrast, we can see now several platforms on the web such as Khan Academy, Udemy, Coursera and other open online courses (Massive Open Online Courses (MOOCs)) have integrated media as an important part of the learning process within these systems. These learning platforms significantly rely on media. Basically, they use screencast videos in order to deliver information to learners to replace face-to-face learning with these online courses. Meanwhile, students are able to learn with these online courses despite not attending these courses physically. Consequently, this prototyped VLE has integrated
media support with other enhanced-media features in order to improve the way that students can improve their learning and understanding experience additionally to their face-face learning in the course. As this VLE is an open learning environment and its learning resources are shared on the web, anyone can benefit from the available learning materials anytime and use lecture screencasts in order to help better understanding of lecture contents.

In this VLE, the lecturer is able to add any sort of media (video, audio, image and screencast) to the course contents. The media can be added to the system’s library, as our system is able to host any sort of media. For example the lecturer could add screencasts with lecture contents to help students better understanding of these contents additionally to the face-to-face lectures. Furthermore, the media can be also imported from the popular social media sites such as YouTube. The support of media in this prototyped VLE has the advantage of using the Media module that is available in Drupal projects.

In addition, we have also added additional enhanced-media features, which will be described below in depth. These features aim to enhance learning by improving the way of publishing educational videos such as lecture’s screencast. These enhanced—media features include adding section/chapter tags, video annotation and movable zoom functions to the videos in this prototyped VLE. All these features have the advantage of using the \textless embedplus \textgreater tool, which offers powerful features for enhancing video embedding (embedplus, 2015).

4.4.2.1 Section Tags

This feature aims to facilitate accessing specific parts of the lecture in screencasts smoothly by dividing the screencasts to sections or chapters based on the lecture structure. Course instructors should take this role by identifying the lecture contents, which can be obtained usually from the second slide (presentation’s agenda) of most lectures presentation handouts. Meanwhile, Learners can look at lecture contents above the video and then decide to move directly to the part that they are interested in as Figure 25 shows. They can move to the next or previous part of the lecture by using Previous/Next buttons like the DVD player as Figure 25 shows. This will save students time during revision sessions to catch specific parts of the lecture in a quick and automatic way.
Lecture Content:

- Part 1: What is HTML?
- Part 2: Why do we need a standards based approach?
- Part 3: What are you going to learn in this course?

Note: you can move to the next or previous part of the lecture by using previous/next buttons like the DVD player.

**Figure 25: Section/chapter tags function**

### 4.4.2.2 Video Annotation

This feature is additional support of the first function to add video annotation for each part of the lecture in the screencast. This annotation can include a description or instruction that can be displayed separately in each section or in a specific slide. It could also contain an external link that can be clicked to direct learners to further resources about this part of the lecture. Figure 26 shows an example of how the video annotation appears in the system. It shows a short description about the specific part of the lecture when moving from each part that was already identified in the past function. However, it is not necessary to use this feature in parallel with the previous function, it could have other annotation options (e.g., external link) in any part of lecture’s screencasts as mentioned above.

**Figure 26: Video annotation function**
4.4.2.3 **Movable Zoom**

This feature is quite useful in screencasts especially for specific course types. For example, programing students would find this feature valuable to zoom in/out to a specific spot in the video player that might be not clear to see in the normal view. It can be also useful to enlarge specific parts of a diagram or an image. Figure 27 shows an example of using this function by zooming in to the code that is unclear in the first part of this figure in the normal view. The second part of the figure shows the result after zooming in to a specific area of the first part of the figure. Meanwhile, the video will still be playing even when using this feature by zooming in/out.

![Figure 27: Movable zoom function](image-url)
4.5 Chapter summary

This chapter presented an overview of our prototyped VLE architecture. It moved then to the deep details of this demonstration VLE architecture. First, it showed the simple data model structure of this VLE. The reason behind maintaining this simple structure of this demonstration platform is because we use this VLE as a research tool in order to implement and test some new technologies and functions that are not available in other conventional VLEs. It does not have all the functions of the existing VLEs such as Moodle and Blackboard, as they are complete tools or products. Instead, we have tried to keep this prototyped VLE as simple as we can in order to facilitate the implementation process and focus mainly on the integrating of the new technologies to this learning platform.

In addition, this chapter also described the content types with their related fields that have been used and added to this VLE. It explained also how this VLE works and the process of creating courses, sessions/lectures, assignments, and forums. Next, this chapter highlighted the specifications of this demonstration VLE. It discussed the diagram that summarises the specifications and features of this platform. As mentioned in this diagram, this VLE is an open learning environment, web users and search engines can access its content freely. This diagram showed also the technologies that have been used and integrated to the prototyped VLE. After that, the structure of content layouts was described with real screenshots from the system for each content type. Meanwhile, we keep the structure of the content layouts as simple as we can to facilitate the reach of educational resources in a smooth way. We also keep the design of the content layouts as “blogs” to work with the current web content structure nowadays in order to facilitate the sharing of this VLE content with other social networking sites. This simplifies also the description of this VLE content with rich semantic information, which will be discussed and described in depth in the next chapter.

We discussed also at the end of this chapter the role of social networking in this prototyped VLE. An example of sharing content within this system to other social networking sites was provided. The importing of user profile information from Facebook and use of this to login to the system were discussed also in this section. Furthermore, the support of media was described with the three enhanced-media features (section tags, video annotation and movable zoom).
Finally, in order to evaluate this prototyped VLE architecture and its new social features, we ran a course in autumn (2013) semester and encouraged students to use this system in parallel with the official university of Surrey’s VLE “SurreyLearn”. We conducted a survey about this VLE’s functions at the end of this course to elicit a feedback from students after they have used the system with this course materials. The survey’s result and the evaluation of this VLE will be discussed in chapter 6 after introducing all functions of this demonstration VLE. In the next chapter, we will discuss the most important and interesting task in this demonstration VLE; enriching this VLE content with rich sematic information based on schema.org vocabularies.
5 An Enhanced Approach to Semantic Markup of VLE Content Based on Schema.org

This chapter focuses on our proposal to schema.org by proposing new vocabularies to describe VLEs content with rich semantic information due the lack in specific vocabularies for VLEs in the current schema. This will make VLE’s content not only more visible and discoverable to the major search engines but in a way that provides more meaningful information. We will use our demonstration VLE, which makes use of the Drupal core framework in order to implement and test this proposal.

This chapter is organised as follows. Firstly, it starts with a broad introduction to the most important task in this thesis project. Next, it discusses the implementation of the semantic markup of this prototyped VLE’s content based on the current support in schema.org. After that, it introduces and discusses our enhancements to schema.org in detail as the main focus of this chapter. Finally, this chapter ends with a short summary of the work that we intend to submit as a proposal to schema.org.

5.1 Introduction

In recent years, we have increasingly seen advanced web technologies such as the semantic web or web of data being used to facilitate reusing and sharing of data on the web (Bizer, Heath, & Berners-Lee, 2009). Very recently, there has been an obvious focus on the use of semantic markup especially after the innovation of schema.org, which is a joint effort between the major search engines, Bing, Google, Yahoo!, and Yandex, to have global and official vocabularies that can be understood by the big search engines. However, there is currently a lack of VLE vocabulary support in schema.org to describe VLEs or online course content with rich semantic data due to schema.org being a new innovation and still evolving. Progress in developing support for describing educational resources with rich semantic data has been proposed by the Learning Resource Metadata Initiative (LRMI), which was just added officially to schema.org in April 2013, as mentioned in chapter 3. The LRMI aims to make it simpler to deliver, discover, and publish quality-learning materials on the web with the confidence that the big search engines will understand this metadata (LRMI, 2015). Basically, they have included new properties such as educationalUse, timeRequired and learningResourceType to the
expressive type schema.org/CreativeWork. They have also created two new types to the schema: schema.org/AlignmentObject and schema.org/EducationalAudience. Of course, VLEs and other online courses will benefit from these learning resources metadata that have included to the schema very recently by LRMI. On the other hand, we found during the implementation of our demonstration VLE even after the recent support by LRMI that there is still a lack of learning terms to cover all VLEs structure vocabularies and hierarchies such as courses, sessions/lectures and assignments. Therefore, we will benefit from the recent and existing vocabularies to propose new vocabularies including new types and properties that are unavailable now with the current version based on VLEs’ need, as schema.org is still evolving and is willing to receive new proposals from the community. This proposal aims to extend to the previous work that has been included in the schema by LRMI in order to provide an enhanced approach to describe learning resources and contents with rich semantic data in a VLE context. Furthermore, this proposal can be also be appropriate for other open online courses such as “Massive Open Online Courses (MOOCs)” to benefit from this proposal to structure their courses’ content with rich semantic information. In addition, both course instructors and students will benefit from this task. Consequently, this will allow course instructors and students to have more accurate and meaningful results when they search within the major search engines. It will help also the course instructor to prepare the course material by searching online for similar courses or materials via the existing search engine as this VLE content is freely open, which can of course support sharing of data and knowledge. It has also a rich semantic data that will help search engines to understand its contents and then can provide more accurate results with a “rich snippet” of the most important content on the page to enable the user to decide whether this page is relevant as mentioned in chapter 2 with some real examples of “rich snippets”. This will also increase the visibility of a VLE’s learning content within the major search engines by providing a machine-interpretable semantics to course data. Furthermore, people from outside the respective institutions will be able to search online via the big search engines for any course or only specific sessions based on their requirements, as this VLE is intended to be freely open to all. As mentioned in chapter 3, all the “conventional” virtual learning environments lack enhanced semantic features and support. Consequently, a Semantic Content Management System “Drupal” was selected in this research to deploy and support the
development of different parts of e-Learning services for higher education institutes. Furthermore, we use an existing module called schema.org that has become available in Drupal after the emergence of schema.org and its recent support for RDFa. This enables us to embed schema.org vocabularies within our VLE webpages HTML code in RDFa format.

We will now discuss the implementation of the semantic markup of this demonstration VLE’s content based on the current support in schema.org and how we benefit from this experience to draw the initial design of our proposal to schema.org. However, the current chapter focuses mainly on our proposal to LRMI and schema.org.

5.2 Semantic markup of VLE content based on Schema.org

As mentioned earlier in this thesis project, this VLE will benefit from the new innovation of schema.org to structure this VLE using Drupal to embed rich semantic markup to its contents. We started to markup the VLE content semantically based on schema.org vocabularies in order to maintain this environment freely open to be accessed via the big search engines in a meaningful way. This will make this VLE content machine-readable and increase the discoverability of its contents as it has been described using an official standard.

We have used our VLE basic structure as already presented in Figure 16 in the previous chapter in order to describe each field in Course, Session, Assignment and Forum with suitable vocabularies in schema.org. As mentioned, we need to propose new classes and properties that are unavailable now with the current version. As a result, we propose to create six new classes and 12 additional properties. Full details of this proposal to schema.org and LRMI will be presented in the next section.

This section is focused mainly on the content types that have already been described with the existing schema.org vocabularies without using any proposed type or property from our proposal. As there is no need to propose new types and properties to these types and there are already available vocabularies in the current schema to describe them with semantic information. On the other hand, the other content types (Course, Session and Assignment) will be described in the next section, as they are involved in our proposal to schema.org and LRMI. We have also tested all types of data in our VLE that have been described by schema.org concepts in the structured data testing tool that is provided by Google which will be shown under each content
type. We will start now with structuring the data of the home page and forums in our demonstration VLE with rich semantic information.

### 5.2.1 Home page

We have marked up our demonstration VLE’s homepage semantically using the existing type WebPage (schema.org/WebPage) that is an extension of the CreativeWork type. We use this type and its properties to add semantic mark-up to the home page of this prototyped VLE. Full details of the properties that have been used to describe this type are described below in table 6 or (schema.org/WebPage) with a short description of each property and its expected type of data. Table 6 shows also the properties of the WebPage type and its root types (CreativeWork and Thing) that can be used to describe the home page of this VLE. These properties will be used to describe the existing content type “Article” properties that we used to structure the home page of this VLE as mentioned in the past chapter. However, it is not necessary to use all these listed properties below to describe the home page of VLEs. Thus, the table below shows the applicable vocabularies that could be used to describe home pages in a VLE context.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties from Thing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>description</td>
<td>Text</td>
<td>A short description of the page.</td>
</tr>
<tr>
<td>image</td>
<td>URL</td>
<td>URL of an image of the page.</td>
</tr>
<tr>
<td>name</td>
<td>Text</td>
<td>The name of the page.</td>
</tr>
<tr>
<td><strong>Properties from CreativeWork</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>about</td>
<td>Thing</td>
<td>The subject matter of the content.</td>
</tr>
<tr>
<td>provider</td>
<td>Organization or Person</td>
<td>Specifies the Person or Organization that distributed the CreativeWork. For example, the education institution that provides this VLE.</td>
</tr>
<tr>
<td>inLanguage</td>
<td>Text</td>
<td>The language of the content.</td>
</tr>
<tr>
<td><strong>Properties from WebPage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>primaryImageOfPage</td>
<td>ImageObject</td>
<td>Indicates the main image on the page.</td>
</tr>
<tr>
<td>specialty</td>
<td>Specialty</td>
<td>One of the domain specialities to which this web page's content applies.</td>
</tr>
</tbody>
</table>

Table 6: Home page properties specification

Furthermore, we have tested the home page content in our demonstration VLE that was shown in Figure 16 in the past chapter using the Google structured data testing
tool to see how the home page content can appear to search engines. Figure 28 shows the extracted structured data of the home page, which has used most properties that are shown above without any warning or error using the structured data testing tool. It shows also that this tool understood the type of this page as “WebPage” and the properties that we used from table 6 such as name, primaryImageOfPage and about.

Figure 28: The result of testing the home page in the testing tool

5.2.2 Forum
As mentioned in section 4.2.4, this type used the available module “Forum” in Drupal 7 projects. Therefore, it has been automatically marked up semantically by default using SIOC and DC ontologies as this VLE was built on the SCMS Drupal 7. For example, sioc:Post is used as a type to describe the content type of this page. Also, dc:title is used as a property to describe the title property of this forum. These two ontologies have already been described briefly in chapter 2. Figure 29 shows the extracted structured data of a forum page in this demonstration VLE, using Google’s structured data testing tool. However, there is an available type in schema.org called BlogPosting (schema.org/BlogPosting) that could be applicable to describe this content type but we keep it as its current default semantic markup description based on this module. Thus, we will not include any further details here about this type as we keep this content type as its default setting. Next, we will introduce and discuss our proposal to schema.org and LRMI in the upcoming section as the main focus of this chapter.
5.3 Our proposal to Schema.org

This section will discuss our proposal to schema.org in detail. This proposal suggests new vocabularies including six new classes and 12 new properties to be embedded with schema.org in order to structure VLEs content with rich semantic information. However, this proposal does not rely only on our VLE structure, it benefits also from the existing educational vocabularies such as Academic Institution Internal Structure Ontology (AIISO) and Teaching Core Vocabulary Specification (TEACH) in order to have a comprehensive semantic structure for VLEs and other online courses. As we mentioned above, our proposal will take into account the recent support by LRMI to describe learning resources with semantic information.

By reviewing the use of learning related terms in existing well-established vocabularies, including LRMI, we have increased confidence that our proposal represents an emerging consensus on term use. An alternative approach could be to mine the web to identify the most used terms. However, currently the absence of semantically marked up MOOCS means the former approach will lead to a proposal that is more representative of the community’s emerging consensus. Figure 30 shows the proposed classes and properties (the green boxes), how they related to the existing schema.org hierarchy and the recent support for educational resources by LRMI. However, Figure 30 does not have the full schema.org hierarchy with all types/classes and properties but it has only the related types to this proposal and some other popular types.
This proposal will rely centrally on the current expressive types CreativeWork and Action, as they have most of the properties that we need to describe our VLE in rich semantic information. Action is a new expressive type, which has many specific types that was just added to schema.org very recently (Brickley, 2014). There are many extended types to CreativeWork and Action; some of them do not have any new properties, as they are very expressive types, which have most properties that might be needed. An example is the Photograph type (extended type to CreativeWork); it does not have any new property but simply puts CreativeWork in a photographic context. Another example is
OrganizeAction type (extended type to Action); it does not have any new property too but simply puts Action in an OrganizeAction context. Therefore, the main reason of this proposal is to add new types (e.g., Course, Session, Examination and Assignment) and limited properties, which do not exist in the current schema to put CreativeWork and Action types in a VLE context. Furthermore, all our new types and properties are extended to these expressive types CreativeWork and Action additionally to their properties. It is suggested by the schema.org extension mechanism to use existing and relevant vocabularies in the schema in order to create new classes or properties. The extension mechanism is to take an item type (class/property) in the current schema, add a forward slash to the end and then add the new extended item in CamelCase for a new class and camelCase for a new property (Schema.org, 2014b). Figure 31 shows how we used the schema.org extension mechanism in this demonstration VLE to extend types/classes and properties using the RDF mapping API in Drupal. However, search engines will ignore these vocabularies until they become included officially in schema.org (Rosati & Mayernik, 2013). We will use our demonstration VLE to markup its contents with rich semantic information in order to implement and test this proposal. We will test our proposal using the Google structured data testing tool in order to make sure that we have used the extension mechanism correctly and see how our VLE contents structure appear to search engines.

In addition, our VLE structure consists of four main classes: Course, Session, Assignment and Forum as presented in the data model diagram (Figure 15) in the previous chapter. Figure 30 shows how the new proposed types and properties can be linked to the existing hierarchy of schema.org. Further details about each new type in

**Figure 31: An example of using schema.org extension mechanism in Drupal 7**

In addition, our VLE structure consists of four main classes: Course, Session, Assignment and Forum as presented in the data model diagram (Figure 15) in the previous chapter. Figure 30 shows how the new proposed types and properties can be linked to the existing hierarchy of schema.org. Further details about each new type in
our proposal and its related properties are discussed in depth in the following subsections.

5.3.1 Course

This new type is extended from the existing class CreativeWork to put this expressive type in a Course context. CreativeWork has most properties that are needed to describe Course fields with rich semantic information. It has also most of the new learning resource vocabularies that were included in schema.org last year by LRMI. Therefore, we have used several existing properties from “CreativeWork” and its root type “Thing” such as name, description, image, provider, inLanguage, typicalAgeRange, and author. Full details about these properties such as their data types and a short description can be found in Table 7 below or (schema.org/CreativeWork). We have used these properties that listed below in Table 7, to embed rich semantic information within the course fields in this VLE that already described in section 4.2 in the past chapter. We also propose new properties for the fields where there are no relevant vocabularies available in the current schema.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties from Thing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>additionalType</td>
<td>URL</td>
<td>An additional type for the item, typically used for adding more specific types.</td>
</tr>
<tr>
<td>description</td>
<td>Text</td>
<td>A short description of the course.</td>
</tr>
<tr>
<td>image</td>
<td>URL</td>
<td>URL of an image that is related to the course.</td>
</tr>
<tr>
<td>url</td>
<td>URL</td>
<td>URL of a resource</td>
</tr>
<tr>
<td>name</td>
<td>Text</td>
<td>The name of the course.</td>
</tr>
<tr>
<td><strong>Properties from CreativeWork</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>about</td>
<td>Thing</td>
<td>The subject matter of the content.</td>
</tr>
<tr>
<td>provider</td>
<td>Organization or Person</td>
<td>Specifies the Person or Organization that distributed the CreativeWork. For example, the education institution that provides this course.</td>
</tr>
<tr>
<td>genre</td>
<td>Text</td>
<td>Genre of the creative work (e.g., Education).</td>
</tr>
<tr>
<td>inLanguage</td>
<td>Text</td>
<td>The language of the content (English, French, etc.).</td>
</tr>
<tr>
<td>typicalAgeRange</td>
<td>Text</td>
<td>The typical range of ages for the contents, for example '7-12'.</td>
</tr>
<tr>
<td>headline</td>
<td>Text</td>
<td>Headline of the course.</td>
</tr>
</tbody>
</table>
Therefore, we propose four new properties to the Course type that are not available in the current schema and it would be significant enhancement to include them in schema.org and LRMI specifications as they are very important properties in any course structure such as the course date and the subject of the course. Table 7 shows in the last section the four new properties to the Course type with their expected types and a short description to each property. Each new property is extended from an existing one, which is a bit relevant to its context, as the schema.org extension mechanism has suggested. For example, subject is extended from the existing property about. courseMaterial is extended from the existing property additionalType. Also, courseDate and courseEndDate are extended from the available property datePublished. This new type Course and its new property (subject) have already used in AIISO and TEACH. However, we use subject here as property not as class like in AIISO.

In addition, we have tested the course page in our VLE, which is shown in Figure 19 in the past chapter using the structured data testing tool that is offered by Google. This allows us to make sure that our demonstration VLE contents are displayed to search engines correctly. Figure 32 shows the results of this testing of the course page which has been described with rich semantic information using most vocabularies that are shown above in Table 7 without any error. It shows that this tool recognised the new type Course and its new properties, which means we have used the extension mechanism in the right way. It shows also how our course contents appear to search engines in a meaningful way.

<table>
<thead>
<tr>
<th>keywords</th>
<th>Text</th>
<th>The keywords/tags used to describe this content.</th>
</tr>
</thead>
<tbody>
<tr>
<td>author</td>
<td>Organization or Person</td>
<td>The author of this content. For example, the course instructor.</td>
</tr>
</tbody>
</table>

**New properties for Course**

<table>
<thead>
<tr>
<th>subject</th>
<th>Text</th>
<th>The subject or the field of the course; for example, ‘Software Engineering’, ‘Medical Physics’.</th>
</tr>
</thead>
<tbody>
<tr>
<td>courseMaterial</td>
<td>URL</td>
<td>Any resource or file for the course.</td>
</tr>
<tr>
<td>courseDate</td>
<td>Date</td>
<td>The start date of the course.</td>
</tr>
<tr>
<td>courseEndDate</td>
<td>Date</td>
<td>The end date of the course.</td>
</tr>
</tbody>
</table>

**Table 7: New Course type semantic properties specification**
5.3.2 Session

This new type is extended from the existing class InteractAction that is a subtype of Action to put this expressive type in a Session context. InteractAction does not have any new property but simply puts Action in an InteractAction context. This new type “Session” fits with the aim of InteractAction, the specific type of Action as described in this type specification (schema.org/InteractAction). However, we propose a Session as subtype of our proposed type LearnAction in order to describe InteractAction in a LearnAction context as this existing type has several specific types such as RegisterAction, UnRegisterAction, SubscribeAction and JoinAction. Therefore, this will put Session type in more sense and semantic structure under specific type of InteractAction. Action has most properties that are needed to describe Session fields. Session will inherit most properties that are needed from InteractAction and its root types (Action and Thing), in order to describe session/lecture contents in rich semantic information.

We have used the following existing properties: name, description, image, agent, startTime, endTime, participant and location to describe...
session fields in rich semantic information. However, the use of `agent` property here in `Session` is different with the use of `author` property (from `CreativeWork` type) in `Course`. `author` is used to describe the course instructor in a `Course`. On the other hand, `agent` is used here to describe the lecturer or the teacher of the session, as there could be different lecturers/teachers for each session within a one course. Full details about these properties such as their data types and a short description can be found in Table 8 below or (schema.org/Action). We have used these properties that listed in Table 8, to describe session/lecture fields in rich semantic information within the session fields in this VLE that already described in section 4.2 in the past chapter. We also propose new properties for the fields where there are no relevant vocabularies available in the current schema.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties from Thing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>additionalType</code></td>
<td>URL</td>
<td>An additional type for the item, typically used for adding more specific types.</td>
</tr>
<tr>
<td><code>description</code></td>
<td>Text</td>
<td>A short description of the session.</td>
</tr>
<tr>
<td><code>image</code></td>
<td>URL</td>
<td>URL of an image of the session.</td>
</tr>
<tr>
<td><code>name</code></td>
<td>Text</td>
<td>The name of the session.</td>
</tr>
<tr>
<td><strong>Properties from Action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>agent</code></td>
<td>Person or Organization</td>
<td>The direct performer or driver of the action. For example, the lecturer or teacher.</td>
</tr>
<tr>
<td><code>startTime</code></td>
<td>DateTime</td>
<td>The startTime of something/action. For example, the start time of the session.</td>
</tr>
<tr>
<td><code>endTime</code></td>
<td>DateTime</td>
<td>The endTime of something/action. For example, the end time of the session.</td>
</tr>
<tr>
<td><code>participant</code></td>
<td>Person or Organization</td>
<td>Other co-agents that participated in the action indirectly. For example, the session/lab demonstrators.</td>
</tr>
<tr>
<td><code>location</code></td>
<td>Place or postalAddress</td>
<td>The location of the even or action. For example, the location of the session.</td>
</tr>
<tr>
<td><strong>New properties for Session</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>sessionMaterial</code></td>
<td>URL</td>
<td>The session files such as handouts and presentation slides.</td>
</tr>
<tr>
<td><code>objectives</code></td>
<td>Text</td>
<td>The objectives or headlines of the session.</td>
</tr>
<tr>
<td><code>courseTitle</code></td>
<td>Course or Text</td>
<td>A citation or reference to the name of the course.</td>
</tr>
</tbody>
</table>

Table 8: New Session type semantic properties specification
We propose three new properties to the Session type that are not available in the current schema and it would be valuable to add them to schema.org and LRMI specifications. Table 8 shows the three new properties with their expected type and a short description to each property. As we mentioned above, each new property is extended from an existing property in the current schema, which is a bit relevant to its context, as the schema.org extension mechanism has suggested. For instance, `sessionMaterial` is extended from the existing property `additionalType`. Also, `objectives` is extended from the existing property `headline`. `courseTitle` is extended from the available property `citation` in order to link the session to its course. Furthermore, `Session` type is not available in AIISO and TEACH like `Course` and `Assignment`. It has been used as a Lecture class in TEACH. However, we use Session here instead of Lecture, as Session has a much broader sense and could be used to describe lecture, seminar, presentation, lab class and tutorial. We could extend the `Session` type with these subtypes but we would like to keep this proposal as simple as we can for the present.

Figure 33: The result of testing a session page in the testing tool
In addition, we have tested one of the session pages in our VLE in the structured data testing tool. Figure 33 shows the result of testing one of the session pages in our VLE that used most properties that are shown above to describe session contents with semantic markup data. This shows also how this testing tool recognised the new properties with their new type Session and how our session contents appear to search engines in a meaningful way.

5.3.3 Assessment

Assessment is a broad expression in an educational context. There is an existing type ReviewAction, which is an extended type of AssessAction that could be used to describe Assessment types. However, there are no available specific types of AssessAction and ReviewAction in order to describe Assessment in an educational context. Therefore, we propose three new specific types of Assessment (Assignment, Examination and Test) that are extended types from the existing type ReviewAction as shown in Figure 30 in order to put this assessment/evaluation type in an educational context. Thus, all these three new subtypes could inherit and use the properties from ReviewAction and its root types (Action and Thing). Full details of these new types are described below in the following subsections. However, we will test only the Assignment type in the structured data testing tool, as it is available and part of our demonstration VLE. The reason to discuss the other common and popular Assessment subtypes (Examination and Test), as this proposal does not rely only the structure of our demonstration VLE. Therefore, the structure of this proposal is also applicable with other open VLEs and online course in order to describe their contents with rich semantic information based on an official standard.

Assignment

As mentioned above, this new type is extended from the existing class ReviewAction that is a subtype of Action/AssessAction as shown in Figure 30 in order to put ReviewAction in an Assignment context. ReviewAction and its root types have most properties that are needed to describe Assignment fields. Assignment will inherit most properties that are needed from ReviewAction and its root types, which is extended from the expressive type Action in order to describe Assignment contents in rich semantic information.
There are several existing properties within ReviewAction or its father types in order to describe Assignment fields in rich semantic information such as name, description, image, agent, startTime, endTime, participant and resultReview. Full details about these properties such as their data types and a short description can be found in Table 9 below or (schema.org/ReviewAction). We have used these properties that listed below in Table 9, to embed rich semantic information within the Assignment fields in this demonstration VLE that already described in section 4.2 in the past chapter.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties from Thing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>additionalType</td>
<td>URL</td>
<td>An additional type for the item, typically used for adding more specific types.</td>
</tr>
<tr>
<td>description</td>
<td>Text</td>
<td>A short description of the assignment.</td>
</tr>
<tr>
<td>image</td>
<td>URL</td>
<td>URL of an image of the assignment.</td>
</tr>
<tr>
<td>name</td>
<td>Text</td>
<td>The name of the assignment.</td>
</tr>
<tr>
<td><strong>Properties from Action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>agent</td>
<td>Person or Organization</td>
<td>The direct performer or driver of the action. For example, the lecturer or teacher.</td>
</tr>
<tr>
<td>startTime</td>
<td>DateTime</td>
<td>The startTime of something/action.</td>
</tr>
<tr>
<td>endTime</td>
<td>DateTime</td>
<td>The endTime of something/action.</td>
</tr>
<tr>
<td>participant</td>
<td>Person or Organization</td>
<td>Other co-agents that participated in the action indirectly. For example, the lab demonstrators.</td>
</tr>
<tr>
<td><strong>Properties from ReviewAction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>resultReview</td>
<td>Review</td>
<td>A sub property of result.</td>
</tr>
<tr>
<td><strong>New properties for Assignment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>deadline</td>
<td>Date</td>
<td>The deadline of the assignment.</td>
</tr>
<tr>
<td>assignmentMaterial</td>
<td>URL</td>
<td>Any resource or file for the assignment.</td>
</tr>
<tr>
<td>courseTitle</td>
<td>Course or Text</td>
<td>A citation or reference to the name of the course.</td>
</tr>
</tbody>
</table>

Table 9: New Assignment type semantic properties specification

In addition, we propose three new properties to this new type as shown in Table 9 in order to have a full semantic description of Assignment. Table 9 shows the three new properties with their expected type and a short description to each property. These three new properties are extended to three existing properties in the schema.org that are a bit relevant to their contexts, as the schema.org extension mechanism has suggested. Deadline is extended from the existing property endTime.
assignmentMaterial is extended also from the existing property additionalType. Also, courseTitle is extended from the available property citation to link the assignment to its course. These three new properties are really important to be included to the Assignment, as most assignments have these fields. Furthermore, this new type Assignment and its new properties (deadline and courseTitle) are already available in the TEACH vocabulary specification.

In addition, we have tested an assignment page in our prototyped VLE via Google structured data testing tool to see how the assignment contents appear to search engines. Figure 34 shows the extracted structured data of the assignment page without any warning or error using the structured data testing tool. This shows also how this testing tool recognised the new properties with their new type Assignment.

![Extracted structured data](image)

**Figure 34: The result of testing an assignment page in the testing tool**

**Examination**

This type of assessment/evaluation can be described as a formal test or summative assessment after a series of sessions, lectures and lessons or after a period of time. This new type is extended from the existing class ReviewAction that is a subtype
of Action/AssessAction as shown in Figure 30 in order to put ReviewAction in an Examination context. ReviewAction and its root types have most properties that are needed to describe Examination fields. Examination could inherit most properties that are needed from ReviewAction and its father types, which is extended from the expressive type Action in order to describe Examination contents in rich semantic information. We propose only one new property to this new type as shown Table 10. courseTitle is extended from the existing property citation in order to link the examination to its course. There are also other existing properties in (schema.org/ReviewAction) and its root types that could be used to describe this new type fields. However, we do not describe these properties again in the table below as they are already mentioned in Table 9 in the past subsection.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties from ReviewAction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>resultReview</td>
<td>Review</td>
<td>A sub property of result.</td>
</tr>
<tr>
<td><strong>New properties for Examination</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>courseTitle</td>
<td>Course or Text</td>
<td>A citation or reference to the name of the course.</td>
</tr>
</tbody>
</table>

Table 10: New Examination type semantic properties specification

**Test**

Test is checking learning after a specific session, lecture or lab class. This new type is extended from the existing class ReviewAction that is a subtype of Action/AssessAction as shown in Figure 30 in order to put ReviewAction in a Test context. ReviewAction and its root types have most properties that are needed to describe Test fields. Test could inherit most properties that are needed from ReviewAction and its root types, which is extended from the expressive type Action in order to describe Test contents in rich semantic information. There are existing properties in (schema.org/ReviewAction) and its father types that could be used to describe this new type fields. However, we do not describe these properties again in the table below as they are already mentioned in Table 9 in the Assignment section. Furthermore, we propose only one new property to this type as shown in Table 11. sessionTitle is extended from the available property in schema.org citation in order to link the test to its session or lecture.

Therefore, this is the key reason for proposing a separate Test type and not including
it with the Examination type, as a Test is usually conducted after a specific session and should be linked to that session. For example, test can be seen obviously in lab classes, as usually there is a test after each lab class especially in programming labs. There is also further type of assessment in an educational context, “Quiz”, which can be listed under the Test type. Quiz is a shorter version of test on a specific topic and could be described as a Test in this proposal.

<table>
<thead>
<tr>
<th>Property</th>
<th>Expected Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>resultReview</td>
<td>Review</td>
<td>A sub property of result.</td>
</tr>
<tr>
<td>sessionTitle</td>
<td>Session or Text</td>
<td>A citation or reference to the name of the session.</td>
</tr>
</tbody>
</table>

Table 11: New Test type semantic properties specification

5.4 Chapter summary

This chapter has presented the implementation of the semantic markup of our demonstration VLE based on the current support in schema.org. It has also discussed our proposed enhancements for schema.org and LRMI to structure VLE content with rich semantic information. We have used our demonstration VLE, which makes use of the Drupal core framework in order to implement and test this proposal. Of course, this could also be implemented with other existing CMSs or LMSs in the future but we selected Drupal because of its advanced semantic support. We have also tested this proposal using Google’s structured data testing tool in order to make sure that we have used the extension mechanism correctly and see how our VLE content structure appears to search engines.

In this proposal, we have proposed six new types (Course, LearnAction, Session, Assignment, Examination and Test) and 12 new properties. These proposed new types and properties are significantly important to structure VLE content and other open online courses with rich semantic information, as there is no equivalent vocabulary available in schema.org for a full structure of VLE content. The main type of this proposal is Course that is extended from the existing and expressive type “CreativeWork” as a course can be described as creative work in context. Also, the CreativeWork type has most of the recent support of learning resources vocabularies that was added to schema.org last year. Furthermore the
Session and Assessment subtypes (Assignment, Examination and Test) are extended from the “Action” specific types (InteractAction and ReviewAction), as they are relevant to these type contexts. This proposal is a conservative extension to schema.org that is informed by the current work of LRMI, AIISO and TEACH. Full evaluation of this proposal and other features in this prototyped VLE will be discussed in the next chapter.
6 Critical Evaluation and Discussion

This chapter aims to provide an evaluation of the VLE functions that have already been presented in the previous chapters of this thesis. This chapter will start first with the evaluation of this demonstration VLE based on students’ feedback. Second, it will evaluate our proposal to schema.org that was discussed in the previous chapter based on a custom search engine. Next, a quick evaluation of the framework “Drupal” that we used to implement this prototyped VLE will be also discussed based on our experience with this semantic CMS. Finally, the chapter will end with a broad evaluation summary and discussion against the research hypothesis and other related work.

6.1 VLE evaluation based on students Feedback

We launched a trial version of this simple VLE in mid September 2013 in order to test its implementation and functions so far. Giving that this trial was performed at the middle stage of this VLE deployment, we were only able to evaluate the first task in this thesis project “Role of Social Networks and Media” due the second task has a proposal to schema.org. However, we have included a general question about the second task within the survey. We gave a name to this prototyped VLE “SocialLearn” during its trials in order to distinguish with the official VLE “SurreyLearn” that is used by university of Surrey and not confuse students while they use both platforms. SocialLearn is used internally as a research tool, and must not be confused with the “SocialLearn” official product from the Open University in the UK.

Meanwhile, we ran only one course “Web Applications Development” in this VLE in parallel with the course contents in the University of Surrey’s own VLE “SurreyLearn” (built on the Desire2Learn LMS). We offered “Level 2” and “MSc” students in the Computing Department at the University of Surrey to access this course via the demonstration VLE. This enabled students to access additional types of content that are not currently supported within the University VLE such as screencasts with additional enhanced media features that have been described in chapter 4. Furthermore, they can also enjoy the social support in the demonstration VLE and access the learning contents via the existing search engines with rich semantic structure.
6.1.1 Survey Design

We tried to keep the survey as simple and short as possible in order to make it convenient for students to fill it in a short time and to obtain more student feedbacks. The survey was designed to start with a general section that has group of questions/factors. This group consists of a number of closed questions about the main features in this demonstration VLE. Basically, the survey included eight factors about the main features in this system. The survey also followed with three open questions to obtain further information. The survey covered the main features and functions in this prototyped VLE and was divided into four questions as shown below in table 12 (also see Appendix A). However, the survey does not require any personal details from students (anonymous) in order to encourage the students to express their opinions about the VLE comfortably and freely.

<table>
<thead>
<tr>
<th>1. If I was using “SocialLearn” to support my studies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I would find the sharing of content with social networking useful.</td>
</tr>
<tr>
<td>b. I would appreciate the availability of &quot;Screencast&quot; helpful.</td>
</tr>
<tr>
<td>c. I would find &quot;section or chapter tags&quot; in screencasts useful to navigate to specific parts of the lecture.</td>
</tr>
<tr>
<td>d. I would find &quot;video annotation&quot; in screencasts helpful to know the topic for each part of the lecture.</td>
</tr>
<tr>
<td>e. I would find &quot;Movable Zoom&quot; in screencasts useful to zoom in/out to particular areas of the video player.</td>
</tr>
<tr>
<td>f. I would find it easy to navigate to lecture contents.</td>
</tr>
<tr>
<td>g. I would make good use of the forum facility.</td>
</tr>
<tr>
<td>h. I would find being able to search for course content via major search engine (Google, Bing and Yahoo) useful.</td>
</tr>
</tbody>
</table>

| 2. Please justify your answer in question 1.a "the sharing of content with social networking in SocialLearn"? |

| 3. Please describe any specific positive and/or negative factors about SocialLearn you would like us to be aware of: |

| 4. Any additional comments? |

Table 12: Survey's design

These questions were answered by students as mentioned above, which helped in evaluating the prototyped VLE from those with different experience and knowledge. A five point Likert scale was used for the first question group: Very Satisfied, Satisfied, Undecided, Not Satisfied and Very Dissatisfied. Additionally, an “Undecided” option was added as a possible answer to ensure the accuracy of other chosen options. Moreover, participants could explain their own ideas through the last
three open questions. This helped to collect additional comments and ideas about students’ experience with this demonstration VLE.

We asked a total of 95 students (22 MSc and 73 Undergraduate students) who enrolled in these two courses to participate in a short survey to evaluate this system. Regarding the login of this VLE, interestingly only four students (4.2%) among the total number of students preferred to login with their Facebook accounts to this VLE rather than creating new accounts. However, this VLE is a freely open environment to access all learning contents and the login is only required for using the forum facility.

6.1.2 Survey results

We received responses from fifty students. Overall, the feedback was positive although very few students disagreed with some factors as Figure 35 shows. Table 13 shows the top features of this VLE in order that have a high review by students based on the mean value that we have calculated from Figure 35. The top functions that most students strongly agreed with are the supporting of media with its enhanced features, except “movable zoom” function. Furthermore, the students were happy with how is it easy to navigate to the lecture content comparing to conventional VLEs as we structured this VLE contents as blogs. They were also very happy with the availability of sharing contents and the searching of VLE’s contents via the major search engines. Several students mentioned in their comments that they are interested with the support of social networking to share learning contents that might be useful to their relatives and friends who are in their social networks. They can also share any problem with their friends or also with the former students of the course. On the other hand, several students were undecided about the “forum facility” and “movable zoom” functions as both these have quite equal score in the evaluation.

In addition, we provide also the standard deviation in order to measure the average of deviation from the mean values in Table 13. When the values in a dataset are dispersed, the standard deviation will be relatively high and vice versa (Numeracy Skills, 2014). Therefore, all standard deviations of this feedback result are quite low compared to their mean values as Table 13 shows. This means that all the values in Figure 35 are pretty tightly bunched together. Especially the D, C and B datasets in Figure 35, as their standard deviations (0.61, 0.69, 0.72) are quite low compared to their mean values (4.12, 4.26, 4.14). It is also clearly visible that the values of the datasets in Figure 35 are tightly bunched together and not spread apart. This is
considered as a good standard deviation, which means there is no high variation in the students’ feedback about the features of this VLE.

![Figure 35: The summary result of the survey](image)

<table>
<thead>
<tr>
<th>Function</th>
<th>Mean Value</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. Video “section tags”</td>
<td>4.26</td>
<td>0.69</td>
</tr>
<tr>
<td>b. Screencast Support</td>
<td>4.14</td>
<td>0.72</td>
</tr>
<tr>
<td>d. Video annotation</td>
<td>4.12</td>
<td>0.61</td>
</tr>
<tr>
<td>f. Easy to navigate</td>
<td>3.98</td>
<td>0.84</td>
</tr>
<tr>
<td>h. Searching for content</td>
<td>3.86</td>
<td>0.80</td>
</tr>
<tr>
<td>a. Sharing of content</td>
<td>3.80</td>
<td>0.85</td>
</tr>
<tr>
<td>e. Movable Zoom</td>
<td>3.64</td>
<td>0.89</td>
</tr>
<tr>
<td>g. Forum facility</td>
<td>3.44</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Table 13: Top Functions order based on students feedback

6.2 Our Proposal Evaluation based on a Custom Search Engine

Most search engines including Bing, Google and Yahoo! offer web users to customise their search enquiries based on popular content types such as images, videos, shopping, books, news, apps or in the whole web in general. This helps web users to obtain more accurate results and the right content types that they are looking for when they search within these search engines. Of course, using relevant vocabularies from
schema.org to describe webpages with rich semantic information will enhance the
discoverability and visibility of these sites from either search engines and web users
in general as described in chapter 3. Therefore, search engines will be able to
recognise the type of these webpages and their contents as they have been described
semantically with the schema.org concepts such as Products, Organization,
Book, Movie, and VideoObject with their relevant properties.

Furthermore, the major search engine “Google” offers webmasters to create their
own custom search engine (CSE) for their users additionally to the basic and
available CSE types (Google CSE Help, 2015). One of the main features this CSE is
to offer webmasters the ability to customise their CSEs by adding extra content types
based on schema.org concepts that are not included yet with the basic custom search
engine. Both proposed or existing concepts in schema.org can be used. The LRMI
project uses this function in order to measure the usage of their vocabularies that have
already been adopted to schema.org (Barker & Campbell, 2014). This CSE allows
webmasters to embed their own CSEs with their site homepages or to share a public
url of this search engine which can be hosted by Google. Additionally, this will help
webmasters to semantically control the results of the search engine based on
schema.org concepts that are already specified.

Of course, this function will help us to evaluate our proposal to schema.org. It will
also help identify how we obtain a more accurate result when we specify this CSE to
search for courses or sessions that are part of our proposal as there are contents for
these types in the trial course in our demonstration VLE as described in the previous
chapter. It will give an obvious example and evidence of the accuracy of results when
we describe VLEs structure and content with rich semantic information. Therefore,
we have created two CSEs based on our proposal concepts; one for Course and the
second one for Session. In this section, we will evaluate and compare the search
enquiries against our demonstration VLE content via these two CSEs and the basic
Google search engine in order to justify the usefulness of adding semantic markup to
VLE content based on broad and supported vocabularies. However, we have also
tested the assessment types in our proposal (Assignment, Examination and
Test) in this CSE and there was no content for these types except very few attempts
of using Test for medical purposes such as blood test. There is a
(schema.org/BloodTest) type available in schema.org. However, it might be that some
webmasters of these websites described their medical pages with the Test type by mistake.

We have used some search keywords in the first CSE, which is based on the main type in our proposal “Course”\(^1\). We will keep the search keywords based on the trial course name “Web Applications Development”. First, we searched for “Web Applications course” in this CSE. We obtained our trial course in the third place among eight results in the search results page as Figure 36 shows. This figure shows also a rich snippet of the photo of our trial course. Further, when we searched for “Web Applications at Surrey, Surrey University or Web course at Surrey University”; we obtained our course in the first result page. In contrast, when we typed the same keywords that mentioned above in the basic Google search engine, we could not find our trial course in the entire results page. However, when we typed the full name of the course with its code (COM2025), it appeared at the beginning of the second results page.

\(^1\) https://www.google.com/cse/publicurl?cx=014084055754064323423:7lpqlukhvmg

In addition, we were surprised to see some use of this concept “Course” by other websites. For example, when we typed a general keyword like “Course” in our CSE, we obtained about 2490 pages that Google was able to recognise that these sites have the schema.org/Course type. The “Course” type/class has already been used within other available ontologies such as AIISO and TEACH. Hence, this might be the reason of these attempts to use this concept as it is not new and is well known term in the existing ontologies.
Also, we have searched for some keywords that are related to the lectures in this trial course in our second CSE. This CSE is customised based on the proposed type “Session” 2. We have searched for a popular keyword “HTML session” that is available in some sessions/lectures within the trial course. We obtained three pages in the results page that are related to this keyword. All these three pages are from our demonstration VLE as Figure 37 shows. In contrast, when we searched for the same keyword that mentioned above in the basic Google search engine, we could not find these pages in the entire results page. We have to use complex keywords such as the full name of the lecture with Surrey or Surrey University to be appeared in the results page. Furthermore, we have tried also to search in our second CSE for other general keywords that are related to this content type but without any result except our VLE’s pages. This could be due to the Session type/class has not been used in the relevant and existing ontologies or vocabularies as explained in our proposal in the past chapter.

![Figure 37: The result of searching for specific Session keywords in Google CSE](https://www.google.com/cse/publicurl?cx=014084055754064323423:2ri5oi5sdym)

These two CSEs provide a simple example of how the major search engine “Google” was able to understand the content of our demonstration VLE after we customised this engine to search for specific webpage types (Course and Session) that are part of our proposal. This justifies the importance and usefulness of adding rich semantic information to webpages based on supported vocabularies in “schema.org”. Basically, these two examples above justify also the important and the need of our proposal to schema.org to semantically structure VLEs content based on the proposed concepts,

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2 [https://www.google.com/cse/publicurl?cx=014084055754064323423:2ri5oi5sdym](https://www.google.com/cse/publicurl?cx=014084055754064323423:2ri5oi5sdym)
as there are no equivalent vocabularies available in schema.org for that purpose. We can imagine now how the proposed semantic VLEs structure presented here will enhance the experience of students and teachers or web users in general when they search for a specific course or session in the web. This can be certainly visible if this proposed semantic VLEs structure has been included to schema.org and has been used also by other open VLEs and other open online course. Of course, this helps the major search engines to be able to understand the content of VLEs and then provide more accurate results and other useful services as these two CSEs above were able to recognised the type of our demonstration VLE pages across millions of sites in the web.

This is also a second proof that we have used the schema.org extension mechanisms in the right way after testing our proposal with the structured data testing tool in the past chapter. We will now discuss and summarise the two evaluations that were described in the first two sections of this chapter against our hypothesis and other related work of this thesis project after evaluating our proposal creation process and the framework that already used to build this semantic VLE in the upcoming section.

6.3 The Proposal Evaluation Process

A fully objective evaluation of our proposed extension to Schema.org would require gathering search results from an extended period of usage across a significant number of users and of online courses. This is not possible within the timeframe of a PhD and must be preceded by a peer evaluation in order to build confidence in the proposal from the community at large. We describe the peer evaluation in this section.

Our proposal to schema.org has passed through different stages of development and evaluation in order to establish a solid proposal to describe VLEs and online courses content. The first stage of this proposal was mentioned earlier; that we found during the implementation of our demonstration VLE that there is still a lack of learning terms to cover all VLEs structure vocabularies and hierarchies such as courses, sessions/lectures and assignments even after the recent support by LRMI. By reviewing the use of learning related terms in existing well-established vocabularies, including LRMI, we have increased confidence that our proposal represents an emerging consensus on term use. Therefore, we started to compare our demonstration VLE structure and the existing educational vocabularies structure in order to have a comprehensive semantic structure for VLEs and not only relying on our own VLE
Also, we studied the schema.org structure in depth in order to link our proposed types to the existing and relevant vocabularies in the current schema. After this initial stage, we started to implement and test this proposal using the demonstration VLE to see how this proposal can be used to describe VLE content in order to provide real examples of implementing this proposal.

We next presented and discussed this proposal with some relevant workshops and conferences in order to elicit a review by the community before submitting it to schema.org and LRMI officially. As result, we had an encouraging and positive feedback, which supported and increased confidence in this proposal. For example, we presented this proposal first at the LINKEDUP Project workshop on Supporting education in the developing world through open and linked data, and we had an encouraging and constructive feedback about the proposal (Aldaej & Krause, 2014a). The workshop’s community also suggested writing a paper about the proposal specifications and presenting it in a very relevant conference. After updating the proposal based on the valuable suggestions from the workshop, we submitted a paper to the 4th Int. Workshop on Learning and Education with the Web of Data (Aldaej & Krause, 2014b). We had also some good suggestions about the proposal from the reviewers after this paper get accepted and before presenting the paper in the conference. After that, we successfully presented this paper, focusing mainly on our proposal to schema.org. There was no further suggestions or concerns about the proposal after presenting this proposal in the conference. The only suggestion that we had during the conference is to submit this proposal to schema.org and LRMI officially as it is ready at this stage for submission after these long stages of development and evaluation of this proposal.

The final stage of evaluating this proposal was to submit the proposal to schema.org and LRMI officially. Therefore, we submitted our proposal to schema.org and LRMI officially on 2nd of November 2014. This allowed us to discuss and show with the decision makers the need and the advantages of adding support for VLEs and online courses in schema.org. The proposal has a wiki page in the W3C site as a requirement of submission (VLEs Wiki, 2014). This wiki page has all the specifications of this proposal with some real examples of the proposal types. Currently, there has been an encouraging discussion within the LRMI community about our proposal and the support of VLEs and online courses in general (LRMI discussion, 2014). Consequently, they have created a group task, which includes our proposal in order to
discuss the previous and current demand from the community to add support for VLEs and online courses (LRMI task group, 2014).

After this overview of the different stages of evaluation of our proposal, this indicates the need of integrating a support for VLEs and online courses in general within schema.org vocabulary as we had encouraging feedbacks before and after the submission of this proposal. We justify also that this proposal does not only represent the structure of our demonstration VLE but also captures an emerging consensus within the community, as it is informed by the current work of LRMI, AIISO and TEACH. Furthermore, it is informed by the valuable and encouraging feedbacks from the community as we had some significant suggestions to make this proposal as solid structure that can be used to describe VLEs and online courses content.

6.4 Drupal Evaluation

This is a quick evaluation of the tool that we used to implement the prototyped VLE with a rich semantic data. This evaluation is based on our experience with this semantic CMS during the implementation of our demonstration VLE. As mentioned in chapter 3, Drupal can be used to create systems and web sites for educational use and can play the role of a LMS (Bratsas, Bamidis, Dimou, Antoniou, & Ioannidis, 2012). Consequently, our experience with Drupal is satisfied and we support this statement that Drupal is a flexible LMS and can play the role of these systems efficiently. It gave us a lot of customisations that we require to structure our demonstration VLE, as Drupal is a good solution for that purpose. We were also able to benefit from the large number of the available modules and extensions to add some extra features and functions to the demonstration VLE as it has a community of thousands of users and developers. For example, as we mentioned in chapter 4, the support of social networking and enhanced-media features that already included to the VLE were benefited by these available modules and extensions.

In addition, as we also mentioned in chapter 3, the key reason to choose Drupal instead of other CMSs or LMSs is because it has advance support of Semantic Web technologies. Therefore, this is the most important point that will be covered in this section as we chose Drupal mainly in this research for this purpose. It was a very comfortable for us to benefit from the semantic web support and use the RDF UI in Drupal 7 to enrich our demonstration VLE with semantic information based on the available support in schema.org. We were also able to implement and test our
proposal to schema.org via our demonstration VLE. It was convenience to enrich this VLE content with our proposal vocabularies. However, there is an important limitation that we explored through our experience with Drupal. We could not mark up more than one type in each page in our demonstration VLE. For instance, we marked up the session pages with only one type “Session” although we could add another type “VideoObject” to the session pages, as there is a video content in all sessions in this VLE. It is possible with schema.org to add more than one type per page in order to describe a single webpage. Therefore, there is a lack of describing a single webpage with more than one type in Drupal 7 based on experience. However, this is not a big issue in our demonstration VLE, as most pages within this VLE require only a single type such as Course, Assignment, Test and Examination.

Based on our experience with our demonstration VLE, the current semantic support in Drupal 7 is applicable for webpages that wish to enrich lightweight semantic information to their pages. Therefore, it is suitable for the simple sites that would like to enrich their pages with a single type in schema.org such as Recipes; Movies; Music; Reviews; TV series. Figure 38 shows an example of describing a simple webpage “Recipe” content with a single type “Recipes” in our demonstration VLE and how this page appears in Google search results. This example demonstrates that search engines were able to understand the semantic content of this page “Recipes” which has implemented using Drupal 7 by highlighting the most important content in this page (Rich Snippets) as this type is already available in schema.org and is not merely a proposed type.

![Apple Pie - SocialLearn - University of Surrey](image)

**Figure 38: An example of a rich snippet for a lightweight semantic page in Drupal**

As Drupal has a large community that works to make Drupal a vital part of the semantic web, we are confident that Drupal 8 will sort out this issue. As mentioned in
chapter 3, this new version will have a default support of schema.org (Corlosquet, 2011b). However, we have already tried to test this issue with the beta version of Drupal 8. Unfortunately, the RDF UI is unavailable with the beta version of Drupal 8 that was available at the time of writing this thesis.

6.5 Evaluation summary against the research hypothesis and related work

As we mentioned at the beginning of this thesis project, it aims to benefit from the development of the web (e.g., Web 2.0, Web 3.0) in order to enhance VLEs, as there has been relatively little innovation in mainstream VLEs in the past few years. As stated also clearly in this research hypothesis, the main motivation in this thesis project is to investigate the sharing of knowledge and data in an educational context, and to make VLEs more open, collaborative and attractive for educational and non-educational institutions. In order to achieve that, we have integrated our prototyped VLE into the wider and social web. Essentially, we added semantic markup based on schema.org vocabularies, and integrated social networking and enhanced-media features to develop and enhance VLEs by improving sharing, discovering and reusing of learning contents, as we have described through the previous chapters. After that, we described in this chapter the evaluation of these semantic and social web technologies that have been presented in the previous chapters including also the Drupal framework for its semantic support. In this section, we will review and summarise these evaluations against the other related work and according to our research aims in this thesis project that were mentioned briefly above.

We will start first with the social and media features that were evaluated earlier in this chapter based on the students’ feedback. Overall, the students were quite satisfied with the social and media features that were adopted in the system. This means that most students are happy to be able to re-produce and share the educational contents to their peers via social networking sites unlike conventional VLEs where the courseware is the only one who can produce these contents (Downes, 2005). This achieved one form of supporting the sharing of knowledge and data in an educational context. Students were also significantly satisfied with the enhanced-media features that were integrated into the demonstration VLE.

The support of media and its enhanced features are really useful for students in order to offer better understanding of the lecture content. Additionally if someone misses
the lecture in the class, as students stated in their feedback, they can still view the material. Given that the students in our trial course used this service as additional support for the physical lectures unlike the learners within the MOOCs sites where usually there is no physical class or lecture and the media is the important part of the learning process within these sites as mentioned in chapter 4. This is an effective way of learning and teaching based on the students’ feedback in our trial course and also given the great success of MOOCs in past few years. This raises an interesting question about the current teaching methods in conventional universities. Instead of having lectures presented in person, the online study material could be made available, with the contact with lecturers through discussion sessions rather than presentation.

The integration of the social and media services that have been presented here in the demonstration VLE can help to solve the problem of the new generation of students with the conventional VLEs as they are looking for more open, collaborative and responsive learning environments (Craig, 2007). It can support one form of improving sharing, discovering and reusing of learning contents in this thesis project. These social and media features also make VLEs more open, collaborative and attractive environments, as the students were satisfied and happy with these features in their feedback as already described earlier in this chapter. Furthermore, the integration of the social and media features in this thesis project is an additional success example of the other positive examples that mentioned in chapter 2 by Franklin & Harmelen of the great advantages of Web 2.0 tools for learning and teaching in Higher Education (2007).

In addition, the second form of sharing, discovering and reusing of learning contents in this thesis project is to enrich our demonstration VLE with rich semantic information based on schema.org, basically our proposed vocabularies, in order to provide a more open learning environment in a machine-understandable context. In order to make our proposal a solid base to structure VLEs and other online courses (e.g., MOOCs) with semantic data. We have evaluated and tested this proposal in several forms.

First, we have used this proposal to describe a real learning environment and we chose our demonstration VLE in order to test the comprehensiveness of this proposal. We have also tried to propose new terms that are well known in the community and make sure that the terms of this proposal are already used in the other relevant
ontologies such as AIISO and TEACH. Also, we have tested this proposal in chapter 5 via the structured data testing tool in order to make sure that we have used the extension mechanism in the right way and to see how our VLE structured data is displayed to search engines. We have also discussed our proposal specifications in some TEL communities to test the acceptability of this proposal and to obtain some useful suggestions in order to enhance the design and the comprehensiveness of the proposal. This is the best way of getting a knowledgeable and scientific feedback by introducing the work to the relevant research communities. The result is that we received encouraging feedback and suggestions from the community that helped us to improve the proposal. These feedbacks and suggestions from the community are a highly appreciated especially the one from the LinkedUp project (http://linkedup-project.eu).

In addition, we have evaluated this proposal in this chapter via the custom search engine in order to provide a real and obvious example of the features of structuring VLEs with rich semantic data based on our proposal to schema.org. This makes finding educational contents from VLEs and other online courses in search engines easier and smarter by customising the search for specific educational content types such as Course and Session as we described in section 6.2. Of course, this improves the discoverability of VLEs content and also adds comprehensive VLEs structure within major search engines as shown in section 6.2. Given also that several commercial leading sites in the web such as “YouTube” and “eBay” already describe their webpages with semantic data based on schema.org in order to improve the discoverability of their contents in the major search engines as we described in chapter 2.

Can we imagine now how the proposed semantic VLEs structure will enhance the experience of students, teachers and web users in general when they search for a specific course or session in the web after this proposal get accepted and approved by schema.org? Furthermore, this is an additional evidence of the important of maintaining VLEs open to search engines. This proposal is almost ready at this stage to be submitted to schema.org and LRMI as it has passed through several long stages of designing, implementation, testing and evaluation in order to make it a solid proposal to structure VLEs with rich semantic data.

Finally, Drupal successfully structured our demonstration VLE with rich semantic data and played the role of LMSs to built this learning platform from scratch. The
current semantic web support in Drupal 7 is ideal for the lightweight semantic webpages based on our experience during the implementation of our demonstration VLE. We could not describe the session’s pages with “VideoObject” additionally to their basic type “Session” as they have screencasts in each session/lecture. Therefore, our session pages will be not displayed in the video custom search engine, as we could not describe them with more than one type/class due to this limitation in Drupal. It is important for session’s webpages including lectures and presentations to be described with a “VideoObject” type additional to their basic type “Session”. As some web users might search for lectures via the video custom search engine because they are looking only for the videos of these lectures and presentations. We are confident that Drupal will solve this issue in the next version “Drupal 8” as it is very important for complex webpages.
7 Conclusions and Future Work

7.1 Submitting our proposal to schema.org and LRMI officially
As mentioned in chapter 3, schema.org offers the ability to extend the current schema and welcomes the receipt of new proposals from the community (schema.org, 2014b). Therefore, the first plan after completing this thesis project is to follow up on the submission of our proposal to schema.org and LRMI as already presented, tested, evaluated and discussed in the previous chapters. This submission makes our proposal officially open to the schema.org and LRMI communities and a working group has been set up to discussed how to progress with our proposal.

7.2 Encouraging other VLEs and open online course to use this proposal
By encouraging other open VLEs and online courses to use our proposal to describe their contents with rich semantic information, this will give the major search engines to understand these contents partially as they are still proposed vocabularies (schema.org, 2014b). This will also facilitate and accelerate the acceptance and the approval of this proposal by search engines as they can see a broad use of this proposal (schema.org, 2014b). We have already started in this task by presenting and publishing this proposal in order to show the important and the advantage of describing VLEs and other online courses with rich semantic information based on schema.org and basically this proposal concepts. We will continue with this task during and after this thesis project.

7.3 Suggesting of “Rich Snippets” to VLEs content
After this proposal get accepted and adopted to schema.org hierarchy, we provide here some suggestions for the “Rich Snippets” of VLEs content in the search engines results page. We have already provided some general examples of rich snippets in chapter 2. These rich snippets of VLEs content will help search engines to display rich snippets of VLEs content such as Course and Session types by highlighting the most important information, which appears under each search result to give students and teachers a sense for what is on the page. This can also help students and teachers to decide whether this course or session is relevant to their search by looking to the rich snippets. Therefore, we provide here some suggestions of rich snippets for the most important types of this proposal (Course and Session) as they have more
content and the chance of searching for their contents in the major search engines is higher. It is also not necessary to have a rich snippet for each type in schema.org types as we mentioned in chapter 3 that Google only supports rich snippets for the following types in schema.org: People; Products; Events; Authors; Applications; Movies; Music; Recipes; Reviews; TV series (Ronallo, 2012). Therefore, it would be very important and valuable to include Course and Session types from our proposal to the supported types that have a rich snippet.

We suggest the following properties (name, image, courseDate and provider) to show rich snippets of the Course type. These properties will highlight the most important content of any course such as the name of the course, relevant image to the course, the course start date and the educational institution that provides the course. It will give students and teachers a sense for what is on the course page in the search results page. On the other hand, for Session, we suggest the following properties (name, courseTitle, agent and video). These properties will also give students and teachers a sense when they search within the major search engines for sessions. The name of the session/lecture, the title of the relevant course that the session belongs to this course, the lecturer or the teacher of the session and the session/lecture video such as screencast if applicable; are the most important properties to be shown in the rich snippets that could help students and teachers to decide whether this session/lecture is relevant to their search enquiries.

7.4 Including some of this proposal types to the default CSEs

As we mentioned in the previous chapters, the major search engines support specific types in their default custom search based on popular content types such as images, videos, shopping, books, news, apps and weathers. These basic custom search engines will limit the search results page based on the content type specified. Of course, it will also provide more accurate results as these sites have been described with the specified types. Therefore, it would be very important to include at least the Course type from our proposal to the major search engines default custom search. Can we imagine the benefits of including the Course type to the basic custom search in the major search engines? This will make searching for courses within the major search engines easier and more accurate with limited results based on the search enquiries. We already provided an example of a custom search engine for the course type in the
previous chapter and we get a limited search results when we searched for the trial course in our demonstration VLE. The reason of suggesting only one type from our proposal to be added to the default custom search in the major search engines is because there are only limited types available in the default custom search, which are the most popular types of the web users. Therefore, we are suggesting the main type “Course” in our proposal to be included with theses supported types in the default custom search in the major search engines, as it would be impossible to include all the other types in our proposal.

7.5 Additional extensions and enhancements to the proposal

Given schema.org being a new innovation and still evolving, our proposal to schema.org passed through several extensions and enhancements during the development of this proposal whether suggestions from the community or any change or enhancement from schema.org. For example, the first design of this proposal is a very conservative as it consists of only three types Course, Session and Assignment based on the structure of our demonstration VLE. After presenting and discussing this proposal with some relevant communities, we had some suggestion from these communities to make this proposal more comprehensive to include further types such as the assessment types.

Another example with schema.org evolving and changing is the session type and the assessment types as they were extended types to CreativeWork. After the new expressive type Action has added to schema.org recently. We have linked the Session and Assessment types to be extended types to the Action type, as it is more relevant to these types than CreativeWork. Therefore, we will continue in the enhancement and extension of this proposal if needed even after schema.org accepts this proposal whether further suggestions from the community or any change or enhancement in schema.org as it is still evolving. Usually, every few weeks schema.org announces for new changes and enhancements whether new types or additional properties to the existing types in the schema.

7.6 Monitoring the semantic structure of this VLE based on the development of schema.org and semantic web technologies

Given that schema.org is still evolving and usually it announces from time to time for new types or additional properties to the existing types in order to cover most the web
content types and properties. Thus, we will monitor the development of schema.org that reflects on our proposal as we mentioned above. Given also that the semantic web technologies is still evolving and is still a hot research topic. Therefore, we will keep our eyes on the evolving of schema.org and also the development of the semantic web technologies in general. This demonstration VLE will benefit from any development in the web in general basically semantic web as long as it will enhance the semantic structure of VLEs and if there are also advantages of integrating these services to the system.

7.7 Additional evaluation of this VLE
As we conducted a short and quick evaluation against this VLE functions at the middle stage of the development of this prototyped VLE. Given also the small number of students who participated in this evaluation as we ran only one trial course. Therefore, we should encourage additional courses to run their courses in this demonstration VLE, which will bring many students and help for further testing and evaluation of the system. We should also conduct an evaluation against the students of each course in this demonstration VLE. These evaluations will help us to evaluate this VLE from time to time and keep the development of system continuing by adding extra-enhanced features based on the students’ need and the state of the art of the new technologies. However, there is a big challenge of persuading course instructors to run their courses in this prototyped VLE due it is an experimental site at this stage. Given also educational institutions usually request course instructors to use their own official VLEs of these organisations.

7.8 Adding extra functions and features to this VLE
As mentioned above that we will evaluate this VLE from time to time in order to keep the innovation of new enhanced features to this VLE continuing. However, we have in mind some new functions that could be included to the system in the near future. The online quizzes after each session is a good practice for students in order to help them in the revising of the course content. The course instructor could encourage students to complete these quizzes by offering some prizes to the best students who achieves the highest marks. The course instructor could check the marks of students after they completed their quizzes online. This is an example of the possible functions that could be added to the system and of course we should add more and more
features based on the evaluation of the demonstration VLE from time to time as long as these services can enhance VLEs and learning in general.

7.9 Upgrading this VLE from Drupal 7 to Drupal 8
As we mentioned in chapter 3 that the semantic and schema.org supports in Drupal 8 is much better with the current support in Drupal 7. Drupal 8 provides default schema.org integration to its core design. Drupal 8 is still in a beta version at the time of writing this thesis project and there is no official announcement when the Drupal’s community will launch this new version. Therefore, after the official release of Drupal 8, we aim to upgrade our prototyped VLE to this new version in order to have better semantic and default schema.org support. We will investigate also if Drupal 8 can solve the semantic limitation of Drupal 7, as we were unable to describe our content types such as session contents with more than one type from schema.org as discussed in the previous chapter.

7.10 Upgrading this prototyped VLE to an official open VLE
As mentioned early in this thesis project, the main aim of this demonstration VLE is to prototype a simple VLE in order to provide a more open, social and semantic structured learning environment. Also, we implemented this demonstration VLE in order to achieve and investigate our research hypothesis and questions. Therefore, our first aim was a very far from making this prototyped VLE as an official and commercial product as we aim in this research to investigate the integration of VLEs with the semantic and social web. However, the idea of converting this prototyped VLE to an official product came to our minds after the encouraging feedback from students after they used the trial course in this system. In order to convert this prototyped VLE to an official product, we should conduct further evaluations and run additional courses to support our decision about this important change. Therefore, our future aim if we have additional encouraging feedbacks is to convert this learning platform to an official VLE. This official system aims to be an open, semantic, social and non-profit VLE.

7.11 Conclusion
In conclusion, we have shown in this thesis project our trial VLE specification and implementation, which has social features and makes use of semantic web technology based around the schema.org and the Drupal core framework. Of course, this
functionality could also be implemented with other existing CMSs or LMSs in the future but we selected Drupal because of its advanced semantic support. We used Drupal as it has a very large community who work together to ensure this customizable CMS tracks the state of art of web technology development as we benefited from using its modules and extensions for the semantic and social services. As we have described in the previous chapters, our demonstration VLE benefited from the advantages of semantic web and social networking support with enhanced-media features in order to provide a more collaborative, semantic, social and open learning environment.

A quick evaluation was conducted to verify the acceptance of the functions from students that are already available on the trial version of this VLE. The evaluation was quite positive about the available social and media features, which encourages us to add more enhanced features to VLEs. This indicates that students are happy to be able to re-produce and share the educational contents to their peers via social networking sites unlike conventional VLEs where the courseware is the only one who can produce these contents (Downes, 2005).

Furthermore, students were also significantly satisfied with the enhanced-media features that were integrated into the demonstration VLE. Given that the students in our trial course used this service as additional support for the physical lectures unlike the learners within the other online courses where usually there is no physical class or lecture and the media is the important part of the learning process. This is an effective way of learning and teaching based on the students’ feedback in our trial course and also given the great success of open online courses (e.g., MOOCs) in past few years. This raises an interesting question about the current teaching methods in conventional universities. Instead of having physical lectures presented in person, the online study material such as lecture screencasts and lab tutorial videos could be made available, with the contact with lecturers through open discussion sessions rather than presentation. This will offer several advantages for students and lecturers. It will provide more learning flexibility for students and lecturers. Students do not need to attend the class/lecture in regular basis with fix timetables. Therefore, they can save their time of attending their lectures at the university by spending more time in their studies at home or anywhere. On the other hand, lecturers will also save their time too from repeating their lectures and speaking the same word every year. Lectures can save their times of repeating almost the same lecture contents each year by improving
the content of their lectures and offering additional lecture materials and supports. Students and lecturers could arrange for a physical open discussion lecture from time to time during the semester in case if some students would like to ask the lecturer some questions about the course materials. Actually, the UK’s Open University has been teaching this way for many years and is extremely successful as mentioned in chapter 1 (Tresman, 2002) (Volery & Lord, 2000).

In addition, we have discussed the advantages of semantic web to provide a more open and semantic learning environment in a machine-understandable context. Essentially, we have described in this thesis project our proposed enhancements for schema.org and LRMI to structure VLEs content with rich semantic information. We justify our proposal as a conservative extension to schema.org that is informed by the current work of LRMI, AIISO and TEACH. We have implemented and tested this proposal using Drupal and the structured data testing tool in order to make sure that we have used the extension mechanism in the right way and see how our VLE contents structure appears to search engines.

Also, we have evaluated this proposal via the custom search engine as discussed in the previous chapter in order to provide a real and obvious example of the features of structuring VLEs with rich semantic information based on schema.org and basically our proposal concepts. Of course, this helps the major search engines to understand the content of VLEs and then provide more accurate results and other useful services such as the “Rich Snippets” based on these semantic structured data. We justify also that the semantic VLE that presented in this thesis project focused and benefited from the state of the art in semantic web current focus on schema.org as it passed through several developments as described in chapter 2. Therefore, it would be very important for VLEs and other open online courses if they wish to make their contents freely open and available on the web to embed their contents with rich semantic information using schema.org vocabularies to show their contents to search engines in a meaningful way.

It is already expected that the semantic web will influence the development of new versions of e-Learning services and systems (Sampson, Lytras & Wagner, 2004). Furthermore, the integration of the social and media services that presented here can also help to solve the problem of the new generation of students with the conventional VLEs as they are looking for more open, collaborative and responsive learning environments (Craig, 2007). We believe that the Semantic VLE techniques with the
social and media services reported in this thesis project will make significant improvements in the e-Learning field compared with current VLEs, and help move e-Learning for a new generation. Finally, we try to maintain this work as a contribution to the technology-enhanced learning community’s main focus in the past few years of sharing and reusing educational resources, as described in (Dietze & Sanchez-Alonso, 2013).
References


Franklin, T., & Van Harmelen, M. (2007). Web 2.0 for content for learning and teaching in higher education. JISC.


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# Appendix A: Survey Design

## Feedback for SocialLearn

1. If I was using SocialLearn to support my studies: *

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
   a. I would find the sharing of content with social networking useful |   ○      |    ○      |   ○    |       ○        | ○        |
   b. I would appreciate the availability of "Screencast" |   ○      |   ○       |   ○    |       ○        | ○        |
   c. I would find "section or chapter tags" in screencasts useful to navigate to specific parts of the lecture |   ○      |   ○       |   ○    |       ○        | ○        |
   d. I would find "video annotation" in screencasts helpful to know the topic for each part of the lecture |   ○      |   ○       |   ○    |       ○        | ○        |
   e. I would find "Movable Zoom" in screencasts useful to zoom in/out to particular areas of the video player |   ○      |   ○       |   ○    |       ○        | ○        |
   f. I would find it easy to navigate to lecture contents |   ○      |   ○       |   ○    |       ○        | ○        |
   g. I would make good use of the forum facility |   ○      |   ○       |   ○    |       ○        | ○        |
   h. I would find being able to search for course content via major search engines (Google, Bing and Yahoo) useful |   ○      |   ○       |   ○    |       ○        | ○        |

2. Please justify your answer in question 1.a "the sharing of content with social networking in SocialLearn"?

3. Please describe any specific positive and/or negative factors about SocialLearn you would like us to be aware of:

4. Any additional comments?

Thank you for taking our survey. Your response is very important to us.