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Usability in User Generated Learning Spaces

An initial project background report submitted to The University of Manchester for the degree of MSc in Advanced Computer Science & Information Technology Management, in the Faculty of Engineering and Physical Sciences

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Abstract

The focus of this work is to help enable learning in shared, collaborative multi-media learning spaces, by improving the facilities of, and the user interface to, the Manchester Personal Learning Environment (the PLE). The PLE and its learning spaces are designed to support learning as a social process: People learn with each other and from each other. The effective design of learning spaces can enhance the way learning takes place and consequently the outcome. Established theories of learning give rise to strategies for learning facilitation. Behaviourism, cognitivism, social constructivism and Papert's constructionism are surveyed as an initial step in seeking informants for the work proposed here. Particularly, the view is taken that for present day learners who in part exist in a Web ecosystem, learning is all about knowledge creation and discovery, sharing and reusing content. Such learners prefer active and participatory learning. This dissertation focuses on improving usability in the PLE's virtual learning spaces to support this kind of learning. Process aspects of implementing improved learning spaces include assuring both usability and pedagogic usability, through a process of ongoing formative evaluation. Some of these process aspects are discussed here. In a pedagogical context, it is important to measure the learner's satisfaction, not only in the product but also with regards to learning goals, including metacognitve processes in setting, refining and realizing those learning goals. Thus the central question of the work proposed here is what principles of educational theory will improve the usability of user generated learning spaces, and how might these be realized in a practical way in the Manchester PLE's virtual learning spaces.

Chapter 1: Introduction

Learning spaces “encompass the full range of places in which learning occurs, from real to virtual; classroom to chat room” (Brown, 2005). The effective design of physical and virtual learning spaces can enhance the way learning takes place and consequently the outcome. With the advancements in technology leading to convergence of platforms and proliferation of high capacity mobile devices, learners are increasingly shifting their preferences for learning environments from the physical to the virtual. For any interactive system that implements virtual learning spaces, usability is a key determinant in uptake. Usability is defined by the International Organization for Standardization (ISO 9241) as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use".

Designing for learning requires an understanding of how learners construct knowledge. Relevant learning theories need to be explored and applied within the learners' context to capture the learning activity in a way "natural" to the learners. Established theories such as social constructivism, constructionism, self-directed learning, communities of practice, etc engender strategies for facilitating learning. However, the context of learning keeps evolving. It is therefore important to re-examine these theories with a view to adapting them to the prevailing contexts in which learning occurs. This becomes more challenging when viewed from the virtual learning perspective. Interestingly, ICT provides a lot of tools that can help us realise our objectives. These ICT tools have been applied in various ways but the question is how usable are they?

This project is concerned with improving usability in user generated learning spaces. User generated learning spaces are “(learning) spaces which are populated with content by one or more learners” (van Harmelen, 2011). This content according to Harmelen “might be learner generated, or co-opted from elsewhere and used unchanged, or modified, or mixed with other content”. Whatever the case might be, the purpose remains the same, “to help the user(s) learn about a particular topic area, or fulfill one or more learning goals” (Harmelen, 2011).

1.1 Project Objectives

The main objective of the project is to investigate usability in user generated learning spaces. The findings will then be applied in improving the usability of virtual learning spaces in a Personal Learning Environments (PLE). As part of this I will be working on improving the User Interface of the learning space in the Manchester PLE; performing development in FLEX® 4 and complementary technologies.

The main objective has been decomposed into mini targets that will act as guiding posts to achieving the main objective. They are as follows:

- To understand the application of relevant learning theories to the design of learning spaces
- To improve active construction of knowledge by users in virtual learning spaces
- To improve self-directed as well as collaborative learning in virtual learning spaces
- To Investigate (by user evaluation) the usability of current Learning Spaces in the PLE
- To develop improved user interfaces (that are being tested by users) for the current learning spaces in the PLE
- To assess and improve by user testing, the usability of the developed user interfaces

1.2 Project Scope

The project scope includes investigating and improving the usability of virtual learning spaces in the Manchester PLE. Usability evaluation for pedagogical applications comprises two parts namely: technical/functional usability evaluation and pedagogical usability evaluation. This involves the use of testing and formative evaluation in iterative process of design & implementation. A careful comparison of various frameworks for usability testing will be made to select the most appropriate one that can be applied. The selected evaluation framework will need to encompass both aspects as much as possible. Where this is not the case, the framework will be adapted to fit in using established theoretical principles from learning and instructional theory. Web usability is also within the scope of the project. This is because virtual learning spaces are mostly implemented on web pages. Consequentially principles of web usability design will be incorporated in the design and implementation of the improved learning space. Finally, evaluation of the improved learning interface will be carried out periodically using formative evaluation with users and reported. Some innovative features of the proposed learning space are as follows:

- The ability to track and highlight changes in the space both in private and collaborative mode
- The ability to undo actions including in collaborative mode, considering the fact that some other actions might have been performed based on the action to be undone.
- The transfer of desirable classroom and informal space characteristics into the virtual learning space such as ambience, immersion principle, attention and motivation theories, layout reconfigurability, knowledge discovery, etc.

1.3 Report Structure

The project has been introduced, the objective and scope defined. The remaining part of this report is structured as follows:

Chapter 2 – Background

This section discusses relevant background materials with the aim of situating the project into a wider research theme. Relevant learning theories and how they apply to learning are discussed. Current trends in learning space design are examined and then finally, usability in learning spaces design with focus on usable virtual learning spaces.

Chapter 3 – Research Method

This section gives a clear description of the project. I present a concise delivery strategy; a 3-phase research methodology; description of proposed tools to be used; project plan and finally a project management plan. Some of the questions answered in this section include (but are not limited to) “What will be done”, “How it will be done”, “which tools will be used”, “what will be delivered” and “how will be evaluated”.

Chapter 2: Background

This chapter explains the background behind this project. Significant learning theories are introduced which generally specify ideal ways to learn and teach. This is followed by discussion on Virtual Learning Spaces. We then turn to the importance of usability in virtual learning spaces and finally conclude with reviewing related work.

2.1 Basic Terminologies

2.1.1 Learning

Being a complex process, it is not easy to define learning. According to Domjan & Burkhard (1993), "Learning is such a common experience that we hardly ever reflect on exactly what we mean when we say that something has been learnt". They went ahead to confirm that "a universally acceptable definition for learning does not exist" (Domjan & Burkhard, 1993). However, in the following definition, they attempted to capture many critical aspects of the concept of learning:

> "Learning is an enduring change in the mechanisms of behaviour involving specific stimuli and/or responses that result from prior experience with those stimuli and responses"

In this definition, Domjan & Burkhard view learning from a behavioural perspective which is usually inadequate in defining learning when considered in isolation. The following definition (commonly used but source cannot be traced yet) provide the missing link by defining learning as "a process that brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views". This definition attempts to capture the process as well as the product. A noteworthy fact in the definition is that learning is a product of the interplay between the cognitive, the emotional and the environmental. However, the environment can affect both emotion and cognition, positively or otherwise. It therefore becomes a very important factor in learning.

2.1.2 Cognition

Cognition has to do with "how our brain works or how our mind works" (Leonard, Noh, & Orey, 2007). Cognition is the psychological result of perception, learning and reasoning. To put it in simpler terms, it is the act of knowing. Cognition can also refer to the process of knowing. So in my own words, cognition can be a "process" as well as a "product". To clarify any ambiguity, when we talk about how the brain works, we are not making a biological reference to the brain, "most cognitive theories are more conceptual and therefore it might be more accurate to talk about how the mind works rather than a biological reference to the brain" (Leonard, Noh, and Orey, 2007).

2.1.3 Theory

The term theory is a frequently used word in everyday vocabulary. However, the meaning of a theory in science is not the same as the colloquial use of the word. Marx (1970) defines a theory as "a provisional explanatory proposition, or set of propositions, concerning some natural phenomena". Leonard, Noh, and Orey (2007) share this "explanatory" perspective. According to them, a theory is "a hypothesis that describes, speculates, or defines a relationship between a set of facts or phenomena through a body of principles, policies, beliefs, or assumptions". It follows from both definitions that there exists a subtle tone of assumption in every theory.

2.2 Learning Theories

A Learning theory attempts to help us understand the complex process of learning by describing how people (and animals) learn. Learning theories have two chief values:

- Providing a vocabulary and a conceptual framework for interpreting the examples of learning we observe.
- Suggesting where to look for solutions to practical problems.

Interestingly, the theories do not provide solutions to practical problems. However, it should be noted that they do direct our attention to important variables that are crucial in finding solutions. The meaning of "Learning" has been discussed in a previous section above. Learning theories are generally categorized under three philosophical frameworks namely:

- Behaviourism
- Cognitivism
- Constructivism

2.2.1 Behaviorist Theories

Behaviorism is a learning theory based on the idea that all behaviors are acquired through conditioning which occurs through interaction with the environment. J. B Watson, widely regarded as the father of Behaviorism, defined learning as "a sequence of stimulus and response actions in observable cause and effect relationships" (Chowdhury, 2006). Thus behaviourism assumes that the learner is essentially passive, responding to environmental stimuli. According to LTKB (2011), "the learner starts off as a clean slate (i.e. *tabula rasa*) and behavior is shaped through positive reinforcement or negative reinforcement." Positive indicates the application of a stimulus while negative indicates withholding of a stimulus, thus learning is observable by the "change in the behavior of the learner" in response to the stimuli (LTKB, 2011) as shown in figure 1 below. There are basically two kinds of conditioning in Behaviorism namely classical conditioning and operant conditioning.

Figure 1 - Behaviourist Model

Behaviorism has been applied in the fields of psychology and medicine but our interest lies in its application in learning improvement. Educational approaches such as applied behaviour analysis, curriculum based measurement, and direct instruction have emerged from this model (Kim & Axelrod, 2005). The original theory of behaviorism is now more commonly referred to as "classical behaviorism". New lines of thought have been extracted from classical behaviorism thus giving rise to Neo-Behaviourism (second Generation) and Social-Behaviorism (Third Generation). Of these two, Social Behaviorism focuses more on learning. It considers learning as a relatively stable behavior modification arising from experience.

2.2.2 Behaviorism in Learning

In Behaviourist approaches, learning is centred on the teacher. The teacher is given the role of transferring his knowledge to the learner which is confirmed done by observing a relative permanent change in the behavior of the learner. This approached is marked by reinforced and programmed learning (LTKB, 2011). According to Standridge (2002), "Behaviorist techniques have long been employed in education to promote behavior that is desirable and discourage that which is not". Below is a summary of some features of a behaviourist learning model:

- Learning is done in small, concrete, progressively sequenced tasks
- Learning is marked by repetition in order to increase retention and speed of learning.
- Consistent use of reinforcements during the teaching-learning process. For instance, with verbal acts such as congratulatory remarks and non verbal reinforcements such as awards.

2.2.3 Cognitivist Theories

Cognitivism as a learning theory looks beyond behaviour to explain "brain" based learning. In other words Cognitivism attempts to improve learning by considering how the human memory works. Cognitivism shares a similarity with behaviourism on the basis that both view knowledge as "given" and "absolute" (LTKB, 2011). However, Cognitivism is based on the assumption that human beings are logical beings and thus make choices that are most sensible to them. Pure cognitive theory largely rejects behaviourism on the basis that behaviorism reduces complex human behavior to simple cause and effect (Fritscher, 2011). However, current trends in past decades have been towards merging the two into a comprehensive "cognitive-behavioural theory" (Fritscher, 2011).

2.2.4 Cognitivism in Learning

Cognitivism approaches learning from a learner-centred perspective. From this perspective, learners need to develop deeper understandings, not just produce the right behaviors (Wortham, 2003). Since these deeper understandings cannot be imposed on learners, they must construct their own mental models with sufficient guide from the teacher. Cognitivism views learning as a change in the learner's understanding, hence the focus is on elaboration. The teacher plays the role of a coach or a facilitator. As a facilitator, he has to provide clues and teach mnemonic strategies (Fortin & Rousseau, 1989), to introduce context. As a coach, he has to constantly evaluate the learner's knowledge to keep the learner as active as possible. Tardif (1992) lists some basic principles that characterize the cognitive learning approach as follows:

- Learning is an active and constructive
- Prior knowledge a crucial factor in learning and believes that knowledge is essentially cumulative.
- Learning permits a link between the new pieces of information and the information already in memory.

2.2.5 Constructivist Theories

Constructivism as a learning theory views knowledge as a "constructed" entity (LTKB, 2011). In contrast to the view that knowledge is absolute and given, constructivism asserts that knowledge is constructed by reflecting on our experiences thus fabricating our own understanding of the world we live in (LTKB, 2011). According to the constructivism paradigm, human learning is an active attempt to construct knowledge based on previous knowledge and the present context. Therefore, every person will construct their own unique set of

knowledge. In other words, no two people will start with exactly the same knowledge base, and no two people will construct exactly the same knowledge structures from given experiences or information.

2.2.6 Constructivism in Learning

Constructivism approaches learning from a learner-centred perspective also. However, learning to the constructivist is "discovery and construction of meaning". In the constructivist view, knowledge cannot be poured in, from one person to another. It holds also, that knowledge does not become part of the learner after memorisation of external objective information but is continuously built as the learner interacts with the outside world thus producing his own interpretations about it. According to DeVries et al. (2002), in most pedagogy based on constructivism, "the teacher's role is not only to observe and assess but to also engage with the students while they are completing activities, wondering aloud and posing questions to the students for promotion of reasoning". This promotes learning by experimentation and exploration, not by being told what will happen. The constructivist pedagogy involves the following characteristics (Richardson, 2003):

- Student-centredness, evident in attention to the individual and respect for students' backgrounds
- Facilitation of group dialogue that explores an element of the domain with the purpose of leading to the creation and shared understanding of a topic
- Provision of opportunities for students to determine, challenge, change or add to existing beliefs and understandings through engagement in tasks structured for this purpose

2.2.7 Social Constructivism

Social constructivism proceeds from Vygotsky's social development theory. Social development theory argues that social interaction precedes development; consciousness and cognition are the end product of socialization and social behavior (LTKB, 2011a). Vygotsky focused on the connections between people and the socio-cultural context in which they act and interact in shared experiences (Crawford, 1996). It follows from the ideas of Vygotsky and others that learning is a social process. This is why the environment within which learning occurs plays a very important role in social constructivism.

Social constructivism emphasizes the benefits of collaborative learning (Fruchter and Emery, 1999). The role of the educator in this context is to provide what is known as "scaffolding". Scaffolding refers to guidelines and hints which help the learner build strong, complex and relevant ideas (Vygotsky and Cole, 1978). The learner progressively removes this scaffolding and tends towards self-directed learning replacing scaffolding with his own ideas and plans.

2.3 Comparison of Learning Theories

Learning theories are based on different assumptions and focus on different perspectives in explaining learning. Nevertheless, they bear close relationship to one another. Learning styles and behaviours may be viewed as existing on a continuum as shown in figure 2 below. While it may be said that most educational models in use today combine concepts that are mostly drawn from cognitivism and constructivism, that does not mean that the behaviourist theories are not still applicable. For example according to Perraudeau (1996 cited in Ughade et al, 2007), "to develop high intellectual level abilities such as analysis or problem resolution, the teacher will tend to privilege constructivist and cognitivist approaches, whereas for information memorization, a behaviorist approach can be better".

Figure 2 - Continuum of Learning Theories

2.4 Learning Space

In defining the term "learning spaces", Malcolm Brown, started out with a question. "What does the term learning space mean? Why not use a classroom instead?" (Brown, 2005). Learning spaces as defined by Brown (2005) "encompass the full range of places in which learning occurs, from real to virtual; classroom to chat room". According to Brown

> "Just a decade ago, classrooms were the primary locus for learning in higher education. Other spaces included the library, the faculty office (for individual mentoring), and perhaps the café in town. But classrooms were by far the single most important space for learning."

However, a great deal has changed over the years with regards to learning theories, styles and activities. Advancements in learning theories have led to a rethink in designing learning environment. The word "room" (as in classroom, lecture room, etc) is no longer descriptive enough as it has been realised that learning can happen everywhere. The term "Learning Space" is increasingly being used to describe places where learning occurs. Information and Communication Technology has also contributed to changing the notion and location of learning as we shall discuss later, thus leading to the evolution of not only modern physical learning spaces but also virtual learning spaces.

2.4.1 Trends in Learning Space Design

"Learning Spaces often reflect the people and learning approach of the times, so spaces designed in 1956 are not likely to fit perfectly with students in 2006" (Oblinger, 2006a). Consequently, there have been moves to redesign learning spaces not only to conform to the advancements in learning theories but to also conform to the new generation of learners which Oblinger and other choose to call the "Net Generation Learners" (Oblinger & Oblinger, 2005). According to Oblinger (2006a), there are 3 driving forces behind the move to redesign learning spaces viz:

- Changes in students
- Information Technology
- Our understanding of learning

This view is also corroborated by Brown and Long (2006). According to them, "three major trends inform current learning space design" viz:

- Design based on **learning principles** (or theories), resulting in intentional support for social and active learning strategies.
- An emphasis on **human-centered** design
- Increasing ownership of **diverse devices** that may enrich learning.

Obviously these agree with Oblinger's views. These trends as pointed out by Brown and Long, "have been catalyzed by constructivism, digital technology, and a holistic view of learning".

The constructivist learning paradigm as earlier discussed focuses on the learner rather than teacher. Thus in constructivism, we drop the "transmitter-centric" mode of learning in favour of the "active construction of knowledge" by the learner. We drop the focus on "teaching" in favour of the focus on "learning". This emphasis on learning according to Brown and Long (2006), means that we must also "think about the learner" in designing learning spaces. Learning Spaces, according to them, "are not mere containers for a few, approved activities; instead they provide environments for people".

Consequently, designing a learning space as an architectural master-piece alone is insufficient for the present day learner. Placing high priority on how the learning space enhances learning is also crucial. This must be what Torin Monahan had in mind when he used the term "**built pedagogy**" to refer to "architectural embodiments of educational philosophies". In other words, "the ways in which a space is designed shape the learning that happens in that space (Chism, 2006). Consider the following examples from Chism:

- A room with rows of tablet arm chairs facing an instructor's desk in front of chalkboards conveys the pedagogical approach "I talk or demonstrate; you listen or observe."
- A room of square tables with a chair on each side conveys the importance of teamwork and interaction to learning.

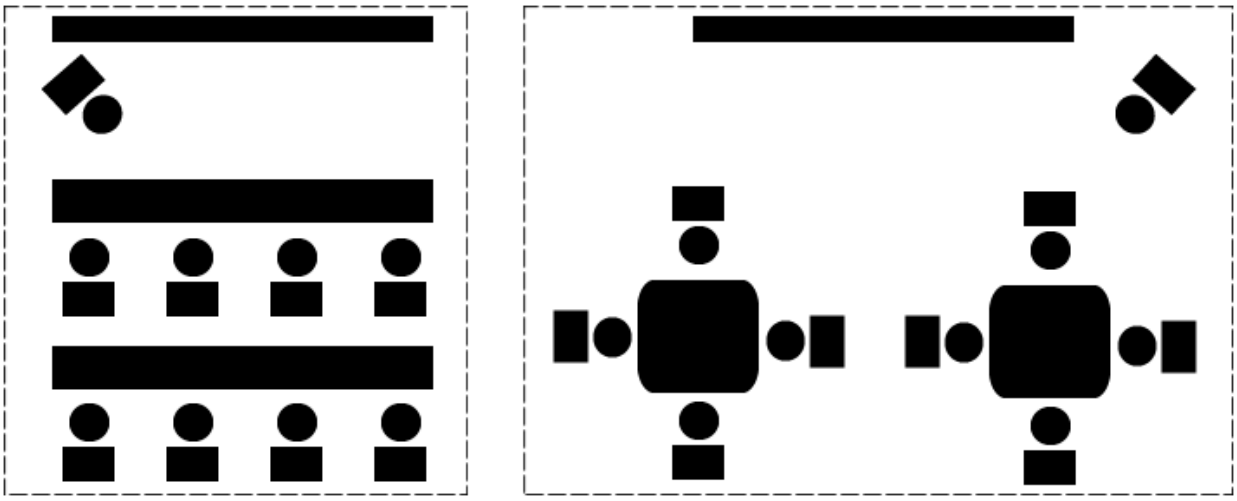

Figure 3 - Linear Arrangement vs. Collaborative Arrangement

Present day students do not like the idea of sitting in front of an instructor like dummies and listening "attentively" to the teaching. Their attention shifts quickly from the instructor to other items such as their mobile devices, course mates, etc. Such learners will definitely not fancy the first example given by Chism above. Oblinger (2006a) describes this kind of learners as favouring "active, participatory and experiential learning". This kind of learning according to Neill & Etheridge (2008), "requires a flexible space", and as such the second example will appeal to them since it is more natural to the learning styles they exhibit in their personal lives.

Information Technology is also another very potent factor shaping the trends in learning space designs. Trends in Information and Communication Technology continuously redefine the meaning, boundaries and styles of learning. The recent proliferation of low-cost devices as well as the integration of platforms has given learners a whole new universe of learning – learning that is distributed in "time" and "space". We focus on this in the next section when we discuss virtual learning spaces. One big problem with technology is the pace of change. The unrelenting pace of technology change, according to Brown and Long (2006) "can make IT decisions rapidly obsolete". Interestingly, "While platforms and applications come and go, the psychology of how people learn does not" (Brown & Long, 2006). This is why the field of "Instructional Technology" focuses on adapting the changing technology to fit the psychology of learning. According to Jonassen & Land (2000), "Technology foundations determine what is technologically possible, but grounded practice requires determination of how capabilities should be exploited". Rather than designing learning to suit the technology, the trends with regards to technology focuses on:

- Designing Technology to support Learning
- Adapting Technology (new and existing) to encourage active, collaborative and experiential learning such as the use of Web 2.0 tools, podcasting, mobile devices, Social Networks, etc.

Current trends in learning space design show the following desired characteristics (Chism, 2006):

- Flexibility
- Comfort
- Sensory Simulation – Colours, Lighting, Ambience
- Technology Support and
- Decentredness

A flexible learning space "better enables innovative approaches to teaching and learning when compared to the traditional classroom" (Neill & Etheridge, 2008). With the right approach, "the entire campus can become a learning space" (Mitchell, 2004). Indeed, in the virtual approach adopted here, both on and off campus learning experiences are to be supported. The 3 trends discussed here underlie this emerging reality (Brown & Long, 2006) while the desired characteristics stated above are the features these trends will produce to support active, participatory and experiential learning.

2.4.2 Virtual Learning Spaces

While physical spaces are tangible and fixed in time and space, virtual learning space is the direct opposite. Also, whereas physical spaces exist around us, virtual spaces exist on machines and devices.

To eliminate all doubts, the term "Virtual Learning Space" doesn't in any way suggest that the "learning" is virtual and not original or authentic. It is the "environment" that is virtual, not the learning. I personally will like to call it "Virtual Spaces for Learning" but for purposes of consistency with the literature stick with "Virtual Learning Spaces".

While there is no single definition for a virtual learning space, most writers define them by specifying their purpose, components and characteristics. Van Harmelen (2011) defines it as "a place where one or more learners can assemble learning materials that are relevant to the pursuit of their learning goals". Such learning materials might be quite diverse, for example, they could be something like a personal development plan

which expiates both learning goals and learning strategies. Alternatively, the content might be a corpus of student work, generated on a particular topic (Van Harmelen, 2011).

It follows therefore that virtual learning spaces are "**designed**" to support and enhance learning through the use of computers, multi-media devices, mobile devices and other technology based tools. Dillenbourg, Schneider & Synteta (2002) suggest the following about virtual learning spaces:

- A virtual learning space is a designed information space.
- It is a social space: educational interactions occur in the environment, turning spaces into places.
- The virtual space is explicitly represented: the representation of this information/social space can vary from text to 3D immersive worlds.
- Students are not only active, but also actors: they co-construct the virtual space.
- Virtual learning spaces integrate heterogeneous technologies and multiple pedagogical approaches.
- Virtual learning spaces overlap with physical environments.

Virtual Spaces are continually being improved to support active, collaborative and experiential learning. The goal in improving virtual spaces is not to use them as replacements for physical spaces as some might wrongly envisage, rather both spaces are meant to be complementary.

2.4.3 Usability of Learning Spaces

Usability is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO 9241-151, 2008). Usability is a "Quality" attribute, therefore in order to define clearly what usability implies in any context, some form of concrete criteria or attributes must be defined through which usability can be measured. A popular model for doing this is based on five quality components or criteria namely learnability, efficiency, memorability, errors and satisfaction.

Jakob Nielsen is a renowned authority in usability engineering. He observes that usability is a "narrow concern compared to the larger issue of system acceptability" (Nielsen, 1993). The diagram below shows the position of usability with regards to system acceptability.

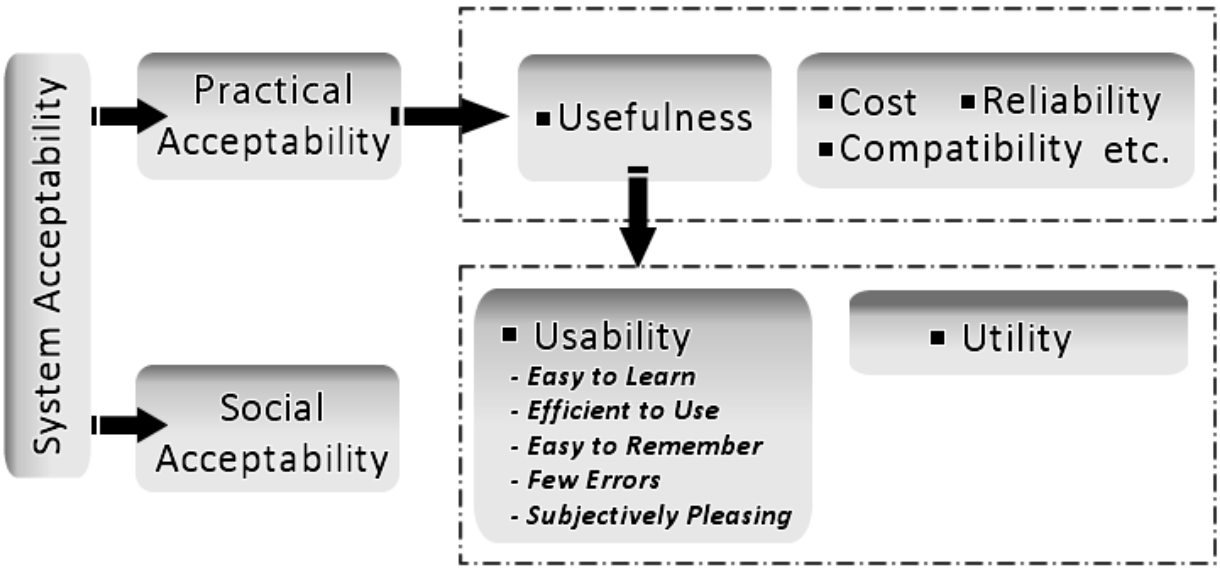

Figure 4 - Attributes of System Acceptability

System acceptability according to Nielsen (1993) “is the question of whether the system is good enough to satisfy all the needs and requirements of the users and other potential stakeholders.” Generally, a system that will be able to “satisfy all” will be a utopian dream. Usually, there is an acceptable level of satisfaction that a system is required to meet. In the framework of social acceptability proposed by Nielsen and corroborated by Ben Shneiderman (1980), Usability, is a defining component of “Usefulness” and is composed of the five attributes identified above which are described below:

- LEARNABILITY: How easy it is for the user to learn to use the system. According to Nielsen (1993), “The system should be easy to learn so that the user can rapidly start getting some work done with it”.
- EFFICIENCY: The level of productivity in use after learning to use the system. In other words, how quickly can the user perform tasks? A high level of productivity is desired in this case.
- MEMORABILITY: The system according to Nielsen, “should be easy to remember”. This will enable the user return to the system after a period of not using it and re-establish proficiency without having to learn about the system from first principles again.
- ERRORS: The error rate of the system should be very low. This does not imply that errors may not occur but if and when they do, how severe are they and how easy it is for the user to recover “gracefully” from these errors. For Nielsen, “catastrophic errors” must not occur.
- SATISFACTION: This is a measure of how “pleasant” it is to use the system. Among all the criteria, this is the most subjective one and is not easy to measure.

For learning support systems, Nokelainen (2006) expanded Nielsen’s usability model by adding “Pedagogical Usability” to the “Utility” branch of the System Acceptability tree and renaming usability to “technical usability”. Nokelainen defines Pedagogical Usability as being “dependent on the goals set for a learning situation by the student and teacher”. It follows thus that evaluating the usability of a virtual learning space becomes more challenging since the technical usability alone is not enough. The environment must also meet the pedagogical demands in terms of achieving learning goals. How do we measure and ascertain that these learning goals have been achieved? Zaharias & Poylymenakou (2009) agree that “evaluating the usability of e-learning applications is not a trivial task”. In order to do a successful usability evaluation, the users, task and context must be identified. According to Zaharias and Poylymenakou, in terms of e-learning, “the main task for the user is to learn, which is rather tacit and abstract in nature”. I believe this is why most e-learning tools have poor usability records. They are either not being evaluated for usability at all or the evaluation is not properly done. To develop an effective usability evaluation framework for virtual learning spaces, the evaluator must familiarize himself with learning theories, learning styles and educational testing research (Zaharias & Poylymenakou, 2009). Three widely used methods for usability evaluation (Hertzum & Jacobsen, 2001) are

- Think Aloud (TA)
- Heuristic Evaluation (HE)
- Cognitive Walkthrough (CW).

Other methods include Questionnaires, Direct Observation, Interviews, Focus Groups, etc.

2.5 Existing PLE Architecture to Support Virtual Learning Spaces

The Manchester Personal Learning Environment (MPLE) is an integrated PLE that aims at providing machine support for people to learn together in collocated and distributed settings (van Harmelen, 2010). Its design is based on social constructivism, Papert's constructionism and self-directed learning which have been discussed above. The MPLE provides a layer of general purpose service which can be used for educational purposes. It also contains multi-user, multi-media spaces that can either be used for personal learning or learning in groups. PLE users may either create and use their own spaces, or join a group with other learners, and meet in community created spaces to pursue common learning activities and realise learning goals (van Harmelen, 2009).

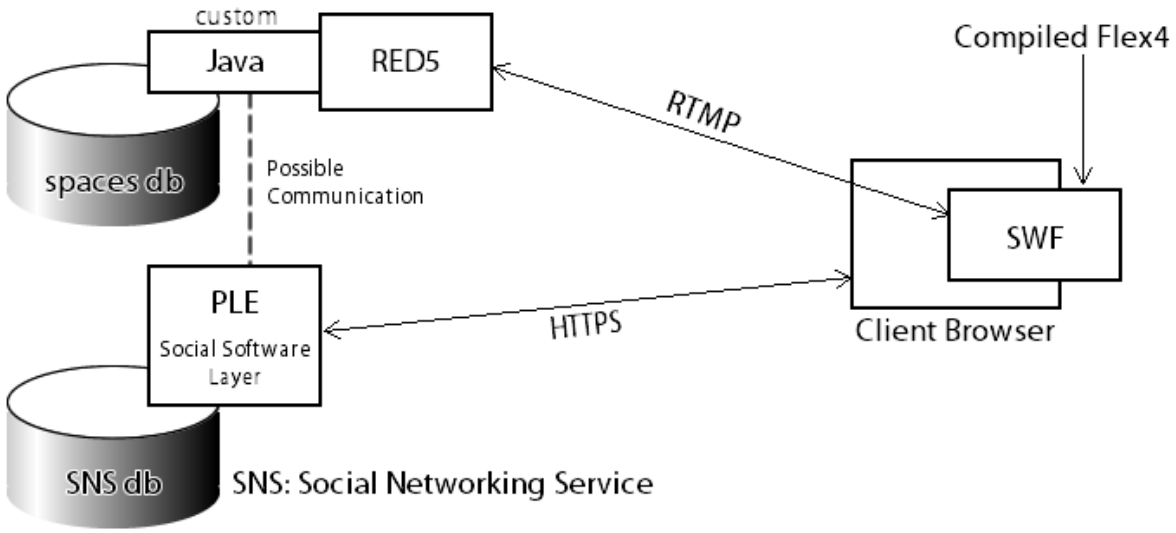

Figure 5 - Overall Architecture of MPLE

The diagram above depicts the architecture of the current MPLE in relation to the media spaces. The media space is written in Flex which compiles to SWF format. This format is executable in Adobe Flash runtime environment available in major web browsers. The spaces connect to a Red5 back end which uses Real Time Messaging Protocol (RMTP) for streaming multi-media content to the spaces. Red5 is written in Java and supports live stream publishing. This enables concurrent editing and updating within the spaces. In previous versions of the Manchester PLE there was some communication from the spaces backend to the PLE social software layer, but this is not exploited currently. Such communication does not involve real-time streaming of media space content. An example can be a notification feed to a user about changes in a shared space.

This architecture will be preserved, as will the use of the Red5 backend. The latter will require modification if this work extends to re-establishing feeds from the spaces to the social software layer.

2.6 Summary

Learning spaces are where learning happens. Great spaces foster great learning whether on physical or virtual spaces. Learning spaces should be designed to enhance learning. Doing this requires that the designers of these spaces understand the principles behind learning which are embodied in learning theories and styles. As more learners shift their focus to virtual learning spaces, it also become necessary to consider the design of virtual learning spaces in order to ensure they meet their pedagogical objectives.

Chapter 3: Research Methods

3.1 Project Description, Delivery Strategy & Evaluation

This section identifies what the project involves, what will be done, how it will be done, what tools will be used and methodologies that will be applied. Expected deliverables and evaluation criteria are also discussed.

3.1.1 Project Description

As discussed in section 1.1 and 1.2, this project involves "improving" the User Interface (UI) for a multimedia, multi-user, collaborative environment. Here, the product to be improved is the "learning space" in a Personal Learning Environment (PLE). The approach will involve taking the existing system and evaluating it by gathering user/expert feedback through cooperative evaluation technique. This feedback will be used to improve the system. Additionally, the feedback gathered will be merged with:

- The Product Owner's vision for the system
- My own visions for the system and
- Ideas from other domain experts

This process will then be repeated in a series of iterations that will lead to an improved and usable product to be delivered at the end of the project.

Improving the usability of any system is not a one off task; rather, it is a process. It involves using a Usability Evaluation Method (UEM) to assess the usability of the system then applying usability design principles and feedback to improve the system. In this case, technical/functional usability will measure aspects such as navigation, error handling and recovery, user interface layout, accessibility, etc. Good Pedagogical usability is also required.

Since learning spaces foster private construction of knowledge as well as collaborative learning, some interesting questions pop up with regards to making the system more usable. Some of which include:

- What is the best way to manage a user's private space and shared space?
- In a shared space, how do we accommodate changes and undo requests given that several users may be working on the same learning resource.
- How do we place emphasis on relevant materials so that the user can immediately locate it on first visit?
- When a user visits a shared or private space and returns to it later, there's a possibility that certain aspects or resources on the space have changed. How do we highlight these changes to the user?
- How do we make it possible for users to invent new components for use in the learning spaces?
- How do we improve the flexibility and adaptability of the learning space?

Another key area to consider is re-configurability and adaptability. Technically, a learning space in the PLE will simply be a canvas with UI components for user generated content. However, the layout of the interface must enable the learner to interact with the space in ways native to his/her learning style. For instance, the learner should be able to use the space as a private classroom, a presentation wall, a resource aggregation platform, a mind map board, etc.

One area I have been considering is transferring some desirable classroom characteristics to the learning spaces. One good example of this is the principle of a "dimly lit" room during presentation. This can be achieved for instance by applying a soft gradient overlay on the page, excluding the area where the presentation is being made. This gives the impression of a "dimly lighted" room and can be very effective. This has been applied on movie and other multimedia streaming websites such as seesaw (http://seesaw.com).

Another characteristic is the principle of "immersion", the ambience and other environmental properties engender learner immersion, thus making the learner relaxed in the learning space. This can be achieved by applying careful layout design principles and colour blending. The use of "full screen mode" also enhances this concept as it removes competing on screen distractions thereby engendering immersion.

Instant feedback is another learning principle that enhances learning and is strongly tied to the motivation theory. Often when using the web, the user has to wait for a page to load and may lose interest and motivation. The use of Flex4 to design the spaces handles this limitation (see development tools in section 3.2.1).

In social or collaborative environments, violation of "Personal Space" is always a consideration worth taking into account. In traditional classroom design, "designers are usually advised to pay attention to the degree to which students feel crowded in a classroom" (Graetz, 2006). Similar notion can be transferred to the design of the learning space by paying careful attention to the crowding of the user interface with widgets. The guiding principle should be, "if it is not needed at the moment, hide it!" Also, being a virtual space, there is no limitation to the amount of learners that can collaboratively share this kind of social space. However, rather than place a hard limit on the number of learners that can share a space at a time, some other interface design principles can be applied. For example, in chat room comprising many people, it is needless to display the list of participants, instead a collapsible container can be used such that the user can expand it when he wishes to see the list and collapse it again thereafter.

3.1.2 Research Methodology

I will follow a 3 phase methodology approach to ensure I achieve the goals of the project. These phases are as follows:

PHASE 1:

This is the "Preliminary Preparation" phase. It includes initial research leading to a broader understanding of the project; identification of related work and tools that can be used to achieve the goals of the project. This process has been ongoing and the submission of this background report brings this phase to a logical conclusion. Next, I will go into a brief period of reflection and evaluation to ascertain that the objectives at this stage have been met. Further discussions with my supervisor will also confirm this and together, we will set the path for progress. The most important artifacts produced in this phase are the project time-plan and the background report. The plan will help me manage the most limited resource which is time while the background report has enabled me to situate my project within a wider research theme thus giving me a broad familiarization with the topic.

PHASE 2:

This phase will officially begin after my exams, though some aspects of it are already in progress. I refer to it as the "Design, Development and Testing" phase. The understanding derived from phase 1 will be used as the basis for design and implementation of the specified software. In keeping up with the project time-plan, tools

for the design have already been identified. Learning to use the tool is also in progress. I have already developed a very deep understanding of the proposed tools. The pending tasks in this phase include the system design, which will be done iteratively together with iterative implementation, testing and evaluation. To ensure a robust system is developed, Test Driven Development (TDD) will be applied to the development process. The Agile Project Management method will be used to ensure that this part of the project is delivered successfully as described in the next sections.

PHASE 3:

The third and final phase of the project which I refer to as the "Report, Review and Submission" phase will cover the writing of the dissertation report. The dissertation report will cover all aspects of the project including some aspects already covered in this background report. The report will also highlight the conclusions drawn from the project, contributions made, deliveries and areas for further research. The figure below presents a graphical overview of the phases and their relationship.

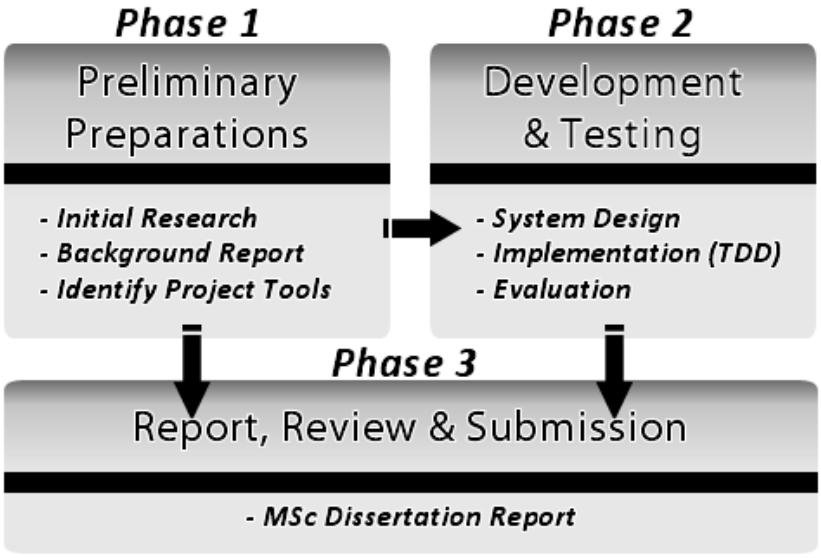

Figure 6 - Research Methodology Flow

Each phase is further split into "**Tasks**". "**Milestones**" are delivered after a set of tasks. The successful delivery of these milestones on or before the deadlines is a clear indication that the project is on course. A list of the milestones is presented below while the project Gantt chart can be found in the appendices (Appendix A).

LIST OF MILESTONES

- Project summary document (due February 17th, 2011)
- Project website (due April 7th, 2011)
- Background report (due May 9th, 2011)
- Periodic evaluation reports (see formative evaluation in section 3.1.4)
- Dissertation report (due September 9th, 2011)

The total time available for this project is 8 months starting from February 1st 2011 and ending September 9, 2011 including the examinations between May 19th and June 8th. As at the time of submission of this report, 50% of this period would have already been gone. It is therefore very important that the tasks in each phase described above progress as outlined in order to ensure I meet the deadline and also deliver a good product fit for a Masters' Project.

3.1.3 Evaluation Plan

This project will be considered successful if all the phases outlined in the research methodology section are completed within the specified time allocated to them. Generally, this will mean that the target goals have been achieved and the expected deliverables delivered.

The type of evaluation being used is formative evaluation. The main purpose of formative evaluation is to strengthen or improve the object being evaluated (RMKB, 2006). It is used in instructional design to assess ongoing projects in order to implement improvements. Formative evaluation and refinement has been ongoing and will continue throughout the process. Formative evaluation can use a variety of techniques. In this case cooperative evaluation (Monk et al, 1993) is being used.

Cooperative evaluation is a variant of think aloud evaluation. The technique encourages design teams and users to collaboratively identify usability issues and their solutions. By encouraging the user to see himself as a collaborator in the evaluation rather than a subject, a more effective form of evaluation is achieved, thus increasing the utility of the data about problems experienced when working with the product. It is very important to note that in cooperative evaluation, the evaluation subject is the product not the user. Cooperative Evaluation will ensure early feedback which will be used to iteratively improve the design and usability of the learning spaces.

The final dissertation report will be evaluated by applying the university research guidelines and regulations to ensure it meets the high standards of the university.

3.2 Project Tools

The project has been described, plans have been made but without the availability of the necessary tools, the expected deliverables cannot be met. This section takes a look at the tools that will be used in the project.

3.2.1 Development Tools

FLEX 4

Flex is "an open source framework for developing intuitive web applications that can make it much easier for people to view and interpret data" (Adobe® Inc). I prefer to use the term Rich Internet Applications rather than intuitive web applications as there is usually a controversy as to whether a web application can actually be intuitive or not. Flex can also be used to build mobile and desktop applications. Applications are built in Flex using MXML tags and Action Script®. They can then be executed in the Adobe® Flash® runtime mostly for web environment and the Adobe® Air® runtime for desktop applications. The Flash runtime is widely available on all major internet browsers while, the Air runtime can be easily downloaded online. Flex

applications running in web pages do not require a page reload to update information on the user interface. They connect to remote server side applications to retrieve data which are used to update the client interface as required. These features make Flex a very suitable candidate for designing learning spaces as required by this project. The latest version of Flex is version 4, this version features a lot of improvement over previous ones especially in enabling modular development. This is the version that will be used.

Adobe ® Flash Builder®

Flash Builder is an integrated development environment for building Flex applications. It was formerly known as Flex Builder and is based on the Eclipse™ IDE Framework. A plug-in also exists that can be installed on any existing Eclipse™ based IDE, however, I prefer the fully functional studio. My supervisor has already obtained Flash Builder for me, and I have been using it to learn how to develop Flex4 applications.

Server Side Tools

Internet applications usually connect to back-end databases to retrieve and display dynamic information. A Flex application does not connect directly to a remote database. Instead, it is connected to a data service written in the developer's favorite web language (PHP, ColdFusion, Java, or any other server-side web technology). This design ensures that Flex applications can be used in any scenario. It also makes it very easy to switch server side implementation without needing to change the front end. As at the time of this writing, I have explored Flex application development with PHP, ColdFusion and Java as the back end service. I propose to use PHP ultimately but this decision may likely change.

Version Control System (VCS)

Version Control also known as Revision control or Source control is a way of managing changes to documents, program source codes or other files. Source control is always very relevant in a collaborative environment where more than person may make changes to a file at the same time. Changes are usually marked by a unique code. The file or group of files being managed can be "branched". This involves making a duplicate copy of the original document and continuing work on the copy while the original remains untouched. A VCS is very relevant in an Agile development environment as it enables majority of the agile methodology ideals to be achieved easily such as continuous testing, integration and release. I am already using **Git** which is a "free & open source, distributed version control system designed to handle everything from small to very large projects with speed and efficiency" (git-scm.com).

3.2.2 Communication & Collaboration Tools

Communication is vital to the success of any project. Interaction and Collaboration are core values of agile and nothing fosters these more than communication. Communication tools have therefore been setup to enable uninterrupted flow of communication among all parties involved. The communication and collaboration media are as follows:

Google Group

A Google group (see http://groups.google.com/) called "newple" has been set up to enable discussion among all parties involved in the design and development of the PLE. This group ensures that everyone gets access to crucial information on time.

Skype®

Skype is a software application that allows users to make voice calls and chats over the Internet (see http://www.skype.com/intl/en-gb/home). Calls made between Skype® users are free. I can communicate with my supervisor and other people involved via Skype.

Scratch Wiki

The scratch wiki (http://nymph.cs.man.ac.uk/scratch) was used to produce my Project summary report, project website and a good part of this background report. The wiki enables me and my supervisor to collaboratively document the project as it progresses. Reports in the wiki can be viewed periodically and used as the basis for defining new pathways in the project.

3.3 Project Management

This section briefly describes plans put in place to properly manage the project in order to ensure its successful completion. A project management plan is relevant to ensure that the project is successful. The Agile Project Management Plan discussed below will be used.

3.3.1 Agile Project Management

Agile project management adapts the ideas from "agile software development" into project management. According to the Agile Manifesto and as seen in practice during one of my course modules, agile methods generally promote collaborative development process that encourages interaction, individuality, stakeholder involvement, feedback, incremental and evolutionary development, periodic delivery of working products, effective control and quick response to change. Agile project management will be used to ensure that the project is managed in an incremental and evolutionary manner until it is successfully completed.

3.3.2 Risk Management & Issue Resolution Plan

Every project is prone to risk. Identifying, analyzing, prioritizing, and controlling project risks are important factors that must not be overlooked. Since I will be using the iterative development method, at the end of each iteration, I will be able to identify risks during the iteration review. I will record the risks identified and develop plans to handle them. Risk control however, is more desirable than risk management; it is better to prevent risks than manage them. Agile methodologies such as scrum are designed to control risk as much as possible. Daily stand up and sprint planning meetings ensure that risks are reduced to the barest minimum.

Chapter 4: Conclusion

In designing learning spaces, the architect uses the landscape as his canvas while the technologist uses electronic devices. What they do not seem to realise is that to the learner, the learning spaces so designed, becomes his own canvas upon which he constructs his learning. What makes a learning space useful and usable? This is the question to bear in mind as I progress in this research project.

The "Net Generation Learners" are evolving learning in very unpredictable ways. When creating learning spaces for this breed of learners, "you can't be sure how these spaces will be used. You are just creating the opportunities for things to happen" (Tom Finnigan cited in JISC, 2006). Their fidelity to technology has become the norm rather than the exception. These learners "appear to have no fear of technology" (Oblinger, 2006a). "Mobile phones, digital cameras, and MP3 players constitute today's backpack. Browsing, downloading, and messaging" is their way of life (Oblinger, 2006a).

According to Oblinger (2006b), "the Internet has changed our notion of place, time, and space" (Oblinger, 2006b). Nevertheless, the "students' comfort with the Internet means it isn't 'technology' to them—it may be a way of life" (Oblinger, 2006a). Consequently, learning spaces are no longer just physical, virtual spaces have come of age. Trends in Information and Communication Technology will continuously redefine the meaning, boundaries and styles of learning. But whereas technology come and goes, the psychology of how people learn is more persistent (Brown & Long, 2006). Therefore, we must return to the pedagogical roots (learning theories and styles) in order to be able to blend technology, learning goals and today's learners' in the right learning spaces.

Oblinger (2006b) recommends involving the users in learning space design. This includes "students, faculty, and staff". This is a vital point because while architects and developers see the complexities involved in realising a design, learners do not. What they see is the kind of learning they wish to have in the environment of their choice. Thus it becomes a challenge to the architect and developer to bring to reality the wishes of the learners. In the case of this project, that architect is the software developer who creates virtual spaces for learners. Exactly how we bring together space, technology, and pedagogy to create usable learning spaces is the focal point of this project. Through this project, I hope to be able to contribute significantly to the support of students who learn in the Manchester PLE's virtual learning spaces, and to generalize from this to contribute to knowledge about "usability in user generated learning spaces".

List of References

Adobe® Systems Incorporated, 2011. *What is Flex*? [online]. Available at: <http://www.adobe.com/products/flex/>. [Accessed 25 April, 2011].

Brown M., 2005. "Learning Spaces". In: D. Oblinger and J. Oblinger, eds. *Educating the Net Generation*. Boulder, Colo.: EDUCAUSE, 2005. Ch. 12.

Brown, M. and Long, P., 2006. "Trends in Learning Space Design". In: D. Oblinger, ed. 2006. *Learning Spaces.* Boulder, Colo.: EDUCAUSE. Ch. 9.

Chism N. V. N., 2006. "Challenging Traditional Assumptions and Rethinking Learning Spaces". In: D. Oblinger, ed. 2006. *Learning Spaces.* Boulder, Colo.: EDUCAUSE. Ch.2.

Chowdhury, M. S., 2006. Human Behavior In The Context of Training: An Overview Of The Role of Learning Theories as Applied to Training and Development. *Journal of Knowledge Management Practice*, 7(2).

Crawford, K., 1996. Vygotskian approaches to human development in the information era. *Educational Studies in Mathematics*, (31), pp. 43-62.

DeVries, R., 2002. *Developing Constructivist Early Childhood Curriculum: Practical Principles and Activities.* New York, Teachers College Press.

Dillenbourg, P., Schneider, D., and Synteta, V., 2002. “Virtual Learning Environments”. *Proceedings of the 3rd Congress on Information and Communication Technologies in Education*, Rhodes, Kastaniotis Editions, Greece, pp.3-18.

Domjan, M., and Burkhard, B., 1993. *Domjan and Burkhard's The principles of learning and behavior*. Pacific Grove, Calif, Brooks/Cole Pub. Co.

Fortin, C., & Rousseau, R. (1989). *Psychologie cognitive: une approche de traitement de l'information* - - .

Fritscher, L., 2011. *Cognitive Theory - Definition of Cognitive Theory* (Reviewed by The Medical Review Board). [online]Available at: <http://phobias.about.com/od/glossary/g/cognitivethedef.htm> [Accessed 16 March 2010].

Fruchter, R. and Emery, K., 1999. Teamwork: assessing cross-disciplinary learning. In: C. M. Hoadley and J. Roschelle, eds. *Proceedings of the 1999 conference on Computer Support for Collaborative Learning (CSCL '99), International Society of the Learning Sciences*, Article 19.

Graetz K. A., 2006. "The Psychology of Learning Environments". In: D. Oblinger, ed. 2006. *Learning Spaces.* Boulder, Colo.: EDUCAUSE. Ch. 6.

Hertzum, M., and Jacobsen, N. E., 2001. The Evaluator Effect: A Chilling Fact about Usability Evaluation Methods. *International Journal of Human-Computer Interaction*, 13(4), pp. 421-443.

Illeris, K., 2007. *How we learn: learning and non-learning in school and beyond*. London, Routledge.

International Organization for Standardization, 2008. *ISO 9241-151: Ergonomics of human-system interaction - Part 151: Guidance on World Wide Web user interfaces*. Geneva: ISO.

Joint Information Systems Committee (JISC), 2006. *Designing Space for Effective Learning: A Guide to 21st Century Learning Space Design* (Bristol, U.K.: Higher Education Funding Council for England, 2006), Available at: <http://www.jisc.ac.uk/uploaded_documents/JISClearningspaces.pdf> [Accessed 15 March, 2011]

Jonassen, D. H., and Land, S. M., 2000. *Theoretical foundations of learning environments*. Mahwah, N.J., L. Erlbaum Associates.

Kim, T. and Axelrod, S., 2005. Direct Instruction: An Educators' Guide and a Plea for Action. *The Behavior Analyst Today*, 6(2), p. 111.

Learning Theories Knowledgebase (LTKB), 2011. *Behaviorism.* [online] Avaliable at: <http://www.learning-theories.com/behaviorism.html> [Accessed 14 April 2011].

Learning Theories Knowledgebase (LTKB), 2011a. *Social Development Theory (Vygotsky).* [online] Avaliable at: <http://www.learning-theories.com/vygotskys-social-learning-theory.html> [Accessed 14 April 2011].

Leonard, K., Noh, E.K., and Orey, M., 2007. "Introduction to Emerging Perspectives on Learning, Teaching, and Technology". In: M. Orey, ed. *Emerging Perspectives on Learning, Teaching, and Technology*. [online] Available at: <http://projects.coe.uga.edu/epltt/> [Accessed 15 March 2011].

Marx, M. H., 1970. *Learning: Theories*. New York, Macmillan Co.

Monk, A., Davenport, L., Haber, J., & Wright, P., 1993. *Improving your human-computer interface: a practical technique*. New York, Prentice Hall.

Neill, S., and Etheridge, R., 2008. Flexible Learning Spaces: The Integration of Pedagogy, Physical Design, and Instructional Technology. *Marketing Education Review*, 18(1), pp.47-53., Available via Business Source Premier, EBSCOhost, [Accessed 17 April 2011].

Nielsen, J., 1993. *Usability engineering*. New York, Academic Press, Inc.

Nokelainen, P., 2006. An empirical assessment of pedagogical usability criteria for digital learning material with elementary school students. *Journal of Educational Technology & Society*, 9(2), pp.178–197.

Norman, D. A., 2000. *The Design of Everyday Things*. London, The MIT Press.

Oblinger D., 2006a. "Space as a Change Agent". In: D. Oblinger, ed. 2006. *Learning Spaces.* Boulder, Colo.: EDUCAUSE. Ch. 1.

Oblinger D., 2006b. "Learning How to See". In: D. Oblinger, ed. 2006. *Learning Spaces.* Boulder, Colo.: EDUCAUSE. Ch. 14.

Oblinger D., and Oblinger J., 2005. "Introduction". In: D. Oblinger and J. Oblinger, eds. *Educating the Net Generation*. Boulder, Colo.: EDUCAUSE, 2005. Ch. 1.

Research Methods Knowledge Base (RMKB), 2006. *Introduction to Evaluation.* [online]. Available at: <http://www.socialresearchmethods.net/kb/intreval.htm> [Accessed 04 May, 2011]

Richardson, V., 2003. Constructivist Pedagogy. *Teachers College Record*, 105(9), pp.1623 – 1640.

Shneiderman, B., 1980. *Software psychology: human factors in computer and information systems.* Cambridge, Mass, Winthrop Publishers.

Standridge, M., 2002. “Behaviorism”. In: M. Orey, ed. *Emerging Perspectives on Learning, Teaching, and Technology*. [online] Available at: <http://projects.coe.uga.edu/epltt/> [Accessed 15 March 2011].

Ughade A., Raffin E., Bouteiller G., Bell I., Cocon P., 2007.*Personal Learning Environment: Design Factors and Implementation*. Msc. The University of Manchester.

van Harmelen, M., 2010. *Short introduction: the Manchester PLE*. [online]. Available at: <http://www.youtube.com/watch?v=Ooy2xR9YcBk> [Accessed 04 May, 2011]

van Harmelen, M., 2011. *Discussion on Usability in User Generated Learning Spaces*. [email] (Personal communication, 27 April 2011).

Vygotsky, L. S., and Cole, M., 1978. *Mind in society the development of higher psychological processes.* Cambridge, Mass. [u.a.], Harvard Univ. Press

Wortham, S., 2003. Learning in Education. *Encyclopedia of Cognitive Science*, Volume 1, Article 563, pp.1079-1082.

Zaharias, P, and Poylymenakou, A., 2009. Developing a Usability Evaluation Method for e-Learning Applications: Beyond Functional Usability. *International Journal of Human-Computer Interaction*, 25(1), pp. 75-98. Available via Business Source Premier, EBSCOhost, [Accessed 11 April 2011].

Appendix A: Project Plan Gantt Chart