

**USABILITY IN USER GENERATED LEARNING SPACES**

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# List of Acronyms

CPD Continual Professional Development

PLE Personal Learning Environment

PDP Personal Development Planning (Planner, Plan)

PSC Private Shareable Component

FLV

F4V

MP4

3GP

MP3

F4A

M4A

AAC

[@TODO Why not just list them in the Appendix of Media Formats – Appendix…..]

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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, information and communication technology (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). The project is motivated by the need to support learning among diverse categories of learners. Doing this raises vital questions which are clearly discussed in the next section.

## 1.1 Research Motivation and Questions

Learning is a continuous process; one does not stop learning (@Ref). However, there are stages in our life when learning is formalized such that one is strictly bounded by rules as to what to learn, when to learn it, how to show that what is required has been learnt and a reward (or otherwise) given for successfully showing it. Apart from this kind of formal system which majorly happens in academic institutions, one can also learn on his own. This kind of learning is referred to as personal learning, personal study, personal development, etc. As an example, a graduate lawyer who majored generally in oil and gas law might become particularly interested in oil financing laws. He does not have to return to law school to get a degree for such knowledge; rather, he takes up a personal study and gets acquainted with the practice of oil financing laws. This kind of scenario is more formally emobodied in what is known as Continuing Professional Development (CPD) (Rughani, Franklin & Dixon, 2003). However, it must not be formal to produce results if properly supported. The challenge is that such kind of personal learning is usually not very effective in the absence of a formal learning framework. This is because there is no external authority mandating the learner to carry out such learning effectively. Nonetheless, the serious learner, for personal reasons will proceed to carry out his personal studies and with the availability of a proper supporting framework, will do it effectively thus reaping the expected outcomes (JISC-CRA, Undated, @Try and Find Date). Such supporting framework can be in form of formal/informal processes, coaching, mentoring, group studies and of course technology. This is where Personal Learning Environments (PLE) comes to play. A personal learning environment can support the learner to achieve his learning goals in many ways. Some examples are given below:

* It can act as a repository of knowledge for the learner
* It can enable the learner to store and bookmark learning resources
* It can provide a social layer where the learner can collaboratively share knowledge with other learners
* It can help the learner monitor progress of his learning
* It can help the learner reflect upon his learning and evaluate the outcome of such learning.

The motivation behind this research project is to support the learner in the ways listed above and in many more ways to achieve his learning goals. In order achieve this, we focus on usability in user generated learning spaces which has already been briefly discussed in the introduction and is further discussed in section (@TODO Which section). The project focuses on how to use interactive virtual learning spaces to support the user in pursuing his personal development in the presence or absence of a formal learning framework. Although there are various interactive multimedia tools in use today for similar purposes, this project is unique in that it does not focus on interactive multimedia technology in isolation; rather, it attempts to lay solid psychological and pedagogical foundations for the tools, processes and methods provided. Consequently, the research seeks to answer the following vital questions:

* Can one use interactive multimedia spaces to actively support a learner in achieving his/her learning goals?
* Can one develop a usable multimedia learning space that will run smoothly despite the limitations of the internet?
* Can a learner develop a personal development plan (PDP) in the multimedia learning space and use it to pursue a learning goal successfully?
* Can a personal development plan so created by a learner be converted to a learning artifact which can be used and/or re-used by other learners to achieve similar outcome(s) as the initial creator/learner?
* Can a learner share his personal development plans and pursue his learning goals collaboratively?
* How can the learner use Private Shareable Components (PSCs) in pursuing his learning goals?
* Can a learner recover components that have been deleted from the multimedia learning space intentionally or mistakenly?
* Can the usability of such multimedia learning space be evaluated by users?
* Is the creation of personal development plans by the learner and the transformation of these plans into explicit learning resources a useful way to support learning?

[@TODO Possibly re-order this list of questions in a more logically flowing manner]

These questions are the motivating factors for this research and they were all answered successfully as can be seen in the concluding section (@TODO Where?). The objectives of the project were set so as to ensure that the research questions raised are properly answered. These are discussed in the next section.

## 1.2 Project Objectives

The target goal 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 Environment (PLE). As part of this I will be working on improving the user interface of the multimedia learning space in the Manchester PLE; performing development in FLEX® 4 and complementary technologies.

In order to ensure the goal of the project is achieved, it has been decomposed into broad objectives that will act as guiding posts to achieving the main goal. 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

This project covers a broad spectrum because it involves designing for learning. However, given the time available for the project, a limited scope that ensures the target goal is achieved successfully was defined.

## 1.3 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 was made to select the most appropriate one that can be applied. Cooperative evaluation was selected for its inherent benefits. This is further reported in section x.x (@TODO Section What?). 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 were incorporated in the design and implementation of the improved learning space. Finally, evaluation of the improved learning interface was carried out periodically using formative evaluation with users and reported accordingly in section x.x (@TODO Section What?). Some innovative features of the improved learning space are as follows:

* Personal development planning (PDP) which enables the learner to take control of his learning. This is discussed in details in section (@TODO Which section?).
* The ability to convert static PDPs to reusable ‘Learning Artefacts’.
* 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 re-configurability, knowledge discovery, etc.

The scope defined above was broadly covered and the target goal of the project was achieved. The rest of this report gives a background of the project as well as design and implementation details. The structure of the report is discussed next.

## 1.4 Thesis Structure

The project has been introduced; the motivation for it given as well as the major questions that motivated the research. The goal and scope has also been clearly stated. The remaining part of this thesis describes how the goal was achieved and 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. Learning theories as we shall see do not only apply to learning but also to the design of learning spaces. This is discussed here also. Current trends in learning space design are examined and then usability in learning spaces design with focus on usable virtual learning spaces is discussed. Finally, a firm theoretical foundation is laid in support of user generated content in learning spaces as well as personal development plans.

**Chapter 3 – System Design 1**

Chapters 3 and 4 cover the design phase of the project. Chapter 3 in particular only covers a part of the system design and is largely devoted to the existing implementation of the multimedia learning spaces in the Manchester PLE. Subsequent chapters cover the design of the new features for the PLE. In this chapter, basic assumptions, problem analysis and design goals are discussed first. An architectural analysis of the existing and proposed system is made. Frameworks, micro-architectures and design pattern (both existing and proposed) involved are also discussed.

**Chapter 4 – System Design 2**

Chapter 4 gives a clear description of design considerations for the main features to be added to the PLE. These include the Twitter Box, Space Painter, Personal Development Planner (PDP), etc. The design of each new component or subcomponent is clearly described.

**Chapter 5 – Implementation**

In order to achieve the kind of rich user experience expected of this kind of system, Rich Internet Application (RIA) platforms were chosen. This section sets out with a proper introduction of the tools of the trade; giving justification for the choice of Adobe Flex ® and complementary technologies. In order to ease entry into the existing code base, some form of code reading and optimising was carried out. This involved debugging certain parts of the existing implementation and also improving the user interaction of existing multimedia components. Having become comfortable with the existing code base, further development was then carried out to implement additional features. This is fully reported in this section also.

**Chapter 6 – Evaluation and Critical Analysis**

This section captures the details behind the evaluation methodology adopted for this project. The strategy as well as the results is reported accordingly. The chapter ends with identification and analysis of the limitations of the system.

**Chapter 7 – Reflection and Future Work**

In this section a brief reflection on the project is done. The research questions are re-visited and a summary of achievements is made. Additionally, areas for future development are identified.

**Chapter 8 – Conclusion**

A run through of the research is done and the project is brought to a logical conclusion.

**Appendices**

**Appendix A:** Contains ….

**Appendix B:** Contains….

# 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.

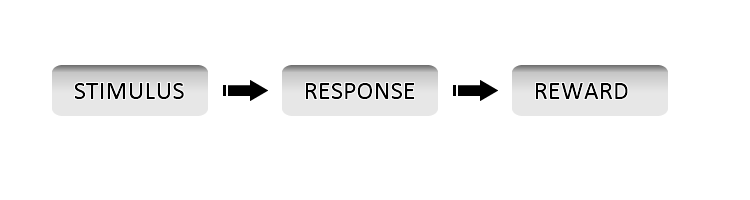


Figure 1 - Behaviourist Model

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”.

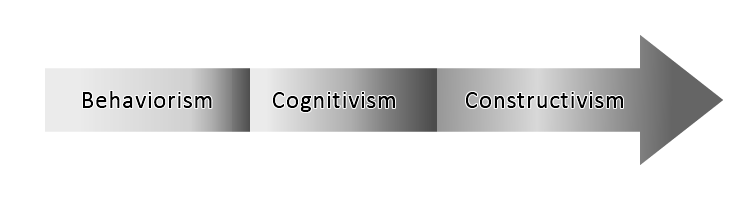


Figure 2 - Continuum of Learning Theories

## 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.

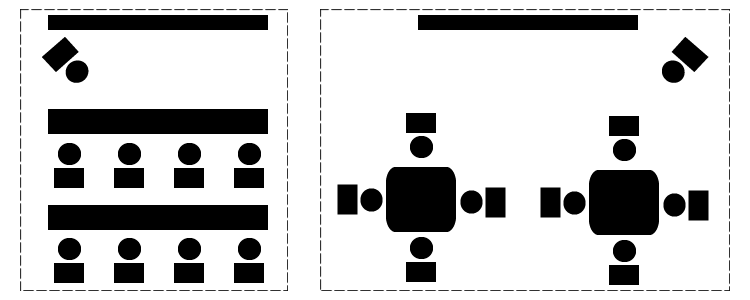


Figure 3 - Linear Arrangement vs. Collaborative Arrangement

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.

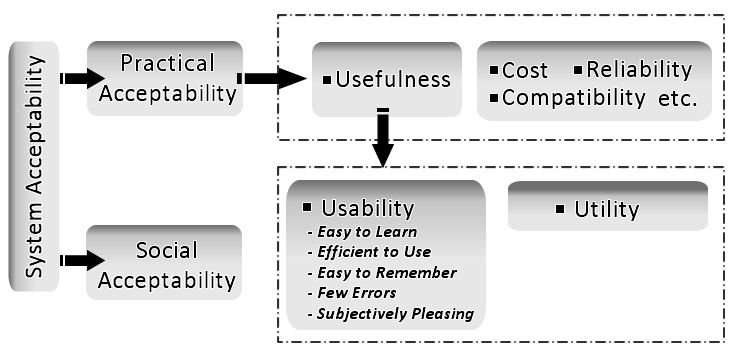


Figure 4 - Attributes of System Acceptability

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.

LEARNING FROM OUR EXPERIENCES

The place of reflection in learning and the importance of it in Personal Development Plans

## 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).

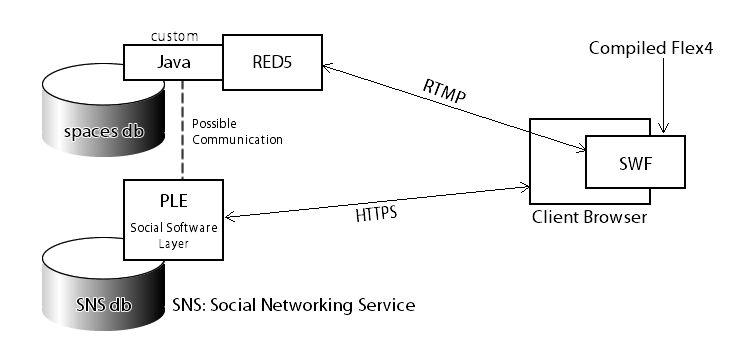


Figure 5 - Overall Architecture of MPLE

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: System Design

This section covers how the theoretical concepts were brought to practical implementation. Due to the nature of work to be done, the design phase was divided into two parts. The first part of the design phase involved understanding the existing system’s architecture and structure. In order to do this an initial study of the existing system was carried out to understand it. Expert reviews were also done to reveal some short comings in the existing system. This led to improvements being carried out in the existing system.

## 3.1 Initial considerations and Assumptions

As already discussed in section (@TODO which section), the main focus of the project is improving usability in user generated learning spaces. User generated learning spaces according to van Harmelen (2011) are “(learning) spaces which are populated with content by one or more learners. This brings some concepts as well as questions to mind but before we attempt to outline any of these, it is very important to state clearly some implicit facts with regards to this definition. The basic assumptions are as follows:

1. The content in the learning spaces can come from a variety of sources
2. The content in the learning spaces needs to be persisted so the learner can continue adding to the knowledge base rather than starting from first principles each time
3. The space is meant to be a collaborative space. This implies that the learner needs to be given the ability to share the content of the space with other learners.
4. In a collaborative mode, other learners should be able to contribute to the content by either generating additional content themselves or modifying already existing content.
5. In collaborative mode, there should be a way to synchronise activities between the learner to ensure that one learners activity does not over-write the others’

In order to ensure that the goals of the project are met, it is important to design the system such that it is easily extensible in the future and this requires a careful analysis of the challenges involved in designing this kind of interactive, collaborative system. This is being discussed in the next section.

## 3.2 Problem Analysis

There is no doubt about the fact that learning with multimedia is fun, however, according to Lindgaard, Brown, & Bronsther (2005), “it takes more than an understanding of technology to design useful and usable multimedia interfaces”. The additional requirement Lindgaard et al were referring to include a broad understanding of learning theories which has already been covered in previous sections. Additionally, they also remarked that one must understand “cognitive models describing how sensory information may be perceived, interpreted, stored, and retrieved when we need it” (Lindgaard, Brown, & Bronsther, 2005). The role of animated and static graphics, the amount of information that should be presented on a page, the ease of use of the system, the visual cues and interactive responses etc all impact the cognitive state of the learner while using the multimedia learning space. All these should be considered carefully in the analysis to ensure the end product is not only a product of technical competence but also pedagogically useful and usable. Research into the learning literature shows that Learning may be described simply as a three-phased process (Mayer 2002 cited in Lindgaard, Brown, & Bronsther, 2005 @TODO, Keep one, kill the other):

1. The learner should select relevant material(s);
2. The learner should organise the selected material; and
3. The learner should integrate it with existing knowledge.

The first phase of this process mostly takes place intuitively. It can sometimes be very easy for the learner to select relevant materials to support his learning. In situations where one cannot easily find relevant materials, a search using the internet, library resources, asking other learners, etc can lead to discovery of sound relevant materials. The second phase is usually where it gets tricky and sometimes complicated. The materials selected or discovered need to be organized is such a way that the following can be met:

1. The materials can be easily identified
2. The relevance of the materials can be easily identified
3. The relationship between the material and other materials identified can be easily understood
4. The source of the material can be identified for further research.

The third phase is more of a cognitive process and given that the second phase is well handled, the third happens almost implicitly. However, I have proposed a fourth phase which should act as a guarantee that the third phase was actually achieved. This phase is known as the ‘reflection’ phase and it involves the learner objectively reflecting on the goals that motivated the learning process in order to ensure that they were achieved. This is discussed further under personal development planning in section (@TODO which section).

@TODO Diagram to show the learning phases.

In order to enable the learner organise his learning materials and easily integrate them into existing knowledge, the multimedia space had to be equipped with basic building blocks that the learner can use to achieve these. These basic building blocks are the media components, the edges and the toolbox.

3.2.1 The Basic Building Blocks

The media components are laid out on a drawing canvas (referred to here as a **‘Whiteboard’**) and organized by dragging, dropping and interconnecting components using edges (directional and non-directional edges). The relationship between the Whiteboard, media components and edges is shown below:

@TODO Diagram to show the relationship between whiteboard components, edges

The diagram shows that the whiteboard can be an unlimited span or area where components can be laid out and interconnected to form an organised body of knowledge. Notice however that the entire whiteboard need not be seen all the time; a viewport is used to visualize a portion of the whiteboard at a time. To clarify any doubt, a viewport is a framed area on a display screen for viewing a specified portion of that screen at any given time. The part of the screen that is visible is the part covered by the area of the viewport. Other parts are invisible until they are brought into view either as a result of a user action or automatically in response to some system event. The user can bring other parts if the white board into focus in the viewport by scrolling the viewport in a horizontal or vertical manner. A better way to do this will be to enable dragging the whiteboard into view. This will eliminate the scrollbars and also provide a more interactive; user friendly user experience to the user. This is because while scrollbars need to be activated at specific points to trigger a response, dragging can be done anywhere on the whiteboard that is unoccupied by a component or an edge. It is important to note that while many viewports are considered to be rectangular, there’s no limitation to the shape a viewport can take, depending on its intended use.

The components as shown in the diagram are displayed on the whiteboard and where necessary are interconnected using edge lines. The edge line can either have a single directional arrow head, bi-directional arrow heads or no arrow head at all. This gives the learner the ability to represent the relationship between the components clearly and further helps in the organization phase of learning.

The toolbox is also a basic item required here. It is a collection of icons which are pictorial representations of the media components. The user elects to display a media component by activating its icon in the toolbox. Figure x.x (@TODO figure what?) shows a sketch of the toolbox as well as a screenshot of its implementation.

@TODO Sketch of Toolbox and implementation Screen Shot

The whiteboard, components and edges are further discussed in section (@TODO which section). The next section examines the design goals of the system.

## 3.3 Design Goals

The design goals of the system revolve around the main objectives of the project as listed in section 1.2 (@TODO Confirm Section, Also Hyperlink Sections). It is important to have clear design goals so as to be able to focus the design and implementation of the system in line with the expected outcome. The main design goal of the multimedia learning space is to allow learners represent knowledge in various formats using visual elements. These visual elements can be textual or graphical. They can be static or animated. In order to achieve this, the elements are represented as components on a whiteboard as described in the problem analysis section (@TODO Link this). The design of the components should be such that the user can easily drop a component on any part of the whiteboard or drag to reposition them on a desired area of the whiteboard. Also, the component should be able to exist in different sizes so that the user can minimize, maximize or drag an edge of the component to resize it to his taste. Finally, with regards to the components, it should be easy to remove a component from the whiteboard when it is no longer needed by the user.

One thing I have not mentioned so far is the process for adding a component type to the whiteboard. In this case, the most widely used approach will be applied. This involves presenting the user with a ‘toolbox’ from which a component type can be selected and then the component should either appear automatically on the whiteboard in its default state or appear when the user clicks on a portion of the whiteboard (maybe drag to lay it out to the desired dimension). The eventual design goal in this case is the former. It is easier and more intuitive to simply make the component appear on the whiteboard as soon as the user selects its representation on the toolbox. In the other scenario, the mouse cursor needs to be changed to signal to the user that something has to be done as a follow up to make the component appear. In many cases however, it is not always intuitive as to whether the user should click or drag to make it appear. Some users may not even realize the need to do any of the above. The chosen plan to make the component appear immediately its representation is selected on the toolbox, is further enhanced by making the component appear at the centre of the whiteboard thereby alerting the user’s attention to the presence of a new item on the screen.

In terms of relationships, edges should be drawn to link components together. In terms of the design goals here, they are as follows:

1. It should be possible to link one component to many other components
2. It should be possible to define a direction for the relationship using arrow heads which can either be unidirectional or bidirectional.
3. It should be possible to label edges using free text to annotate the relationship between components.
4. It should be possible to route edges so that they can trace a flexible path between two components.

There are also design goals for the system in terms of interaction and collaboration. One such design goal is the ability to use a remote cursor controller to track the movement of other users’ mice around the whiteboard. This is a useful feature as each user will be able to see the position of the fellow users’ mouse cursors and as such be able to pre-empt their actions. Additionally, during a presentation, a user can use such functionality to point to elements on the screen while explaining them to the remote audience. The remote cursor can be displayed as a shape (e.g. a small oval or rectangular shape) on the whiteboard but an additional design goal is to attach the user identity to it such that in the presence of multiple remote cursors, the user can distinguish one from another. Another design goal with respect to user interaction and collaboration is the ability to synchronise activities and changes in the learning space among collaborative users. Changes initiated by one user should be immediately updated on the screens of other users. This task requires a careful design of the system as it can be tricky to do this due to the intrinsic concepts behind synchronization such as locking mechanisms and network considerations.

The design goals discussed so far may not be easily achieved given the time frame for the project. Fortunately, some of the goals described have already been achieved in the existing system. Extending and improving the existing system in order to achieve the other design goals therefore become a less difficult task. The next section examines the architecture of the existing system which will give a clearer picture of how some of these goals were achieved. Frameworks, design patterns and concepts used are fully explored here.

## 3.4 Architecture and Layout

The architecture of the existing system was design carefully in line with most of the goals discussed above. The design ensured that every part of the system is cohesive and well decoupled from other parts to foster extensibility. This section gives a clear description of how the system is structured and describes each part that makes up the system.

### 3.4.1 Media Spaces Architectural Overview

In section x.x (@TODO state clearly the section), the overall architecture of the Manchester Personal Learning Environment (MPLE) is given and the diagram (figure x @TODO), shows the relationship between the multimedia learning space and other parts of the PLE. In this section, the architecture of the multimedia learning space is discussed showing the different components that work together to deliver the functionality of the multimedia learning space.

The learning space is made up of three components viz:

1. The Media Server
2. The Space Client
3. The RTMP Connector

@TODO Diagram to show the connection between the three of them

<http://help.adobe.com/en_US/FlashMediaServer/3.5_TechOverview/WS5b3ccc516d4fbf351e63e3d119ed944a1a-7ffa.html> (Ref as Adobe 2009, alphabet where necessary)

The media server is a connection hub. The basic principle behind the media server is that it acts as a central resource point for all connecting clients and thus enables them to share real time information as well as enjoy integrated real-time communication. Using a media server, an application can stream live and on-demand content quickly and easily to a wide variety of platforms and devices (Adobe, 2011 @TODO Cross Compare with Previous Adobe Refs). The following are some of the things that can be done using a media server:

* Live Stream Publishing
* Streaming Video (FLV, F4V, MP4, 3GP) e.g. Live video broadcasts
* Streaming Audio (MP3, F4A, M4A, AAC)
* Recording Client Streams
* Shared Objects which allows clients to interactively share resources in real time.
* Remoting

The abbreviations used above are fully listed in section (@TODO which section, Link it). Flash based applications connect to the media server using Real Time Messaging Protocol (RTMP). This is discussed further below. When connected, the server can exchange (send and receive) data with the connected client applications. It can also invoke methods on target clients. The clients on the other hand can initiate Remote Procedure Calls (RPC) on the server side (Adobe, 2011). Data is transported between clients and server using standard ActionScript objects in Action Message Format (AMF) or other supported formats. Examples of media servers include:

* Adobe® Flash® Media Server (<http://www.adobe.com/products/flashmediaserver/>)
* Red5 Open Source Media Server (<http://trac.red5.org/>)
* Wowza Media Server (<http://www.wowza.com/>)

The existing system uses the Red5 open source media server.

The space client is the flash application that is executed in the user’s browser. The space client is written in ActionScript 3.0 and Adobe® Flex® MXML. The space client acts as the interface between the user and the system. Components are instantiated and organised on the client application while data needed to populate these components are persisted on the server in a database. Due to the collaborative nature of the system, data must be persisted in the server immediately it is inputted into the client components. This will allow other users of the space to be notified of the changes and be updated in real time. A screen shot of the existing space client is shown below.

@TODO Screen shot of existing space client

The Real Time Messaging Protocol (RTMP) connector also referred to as the ‘Red5Connector’ in this system, manages the communication between the media server and the client application. RTMP is a protocol initially developed by Macromedia (acquired by Adobe) for “high-performance transmission of audio, video, and data between Adobe Flash Platform technologies, including Adobe Flash Player and Adobe AIR” (Adobe, 2011B). The specification of the protocol was later released by Adobe for public use.

@TODO Types of RTMP connections and comparism between those three (<http://askmeflash.com/article/10/comparison-wowza-vs-fms-vs-red5>)

(More About RTMFP: <http://askmeflash.com/article/3/real-time-media-flow-protocol-rtmfp>)

The architectural structure of the multimedia learning space is very flexible such that any of the components can be easily extended or even replaced to give the system enhanced functionalities. A good example of this is this project which focuses development on the space client, improving the existing components, adding new components and also enhancing the user interaction experience of the space client. The subsequent sections take a closer look at this part of the architecture, describing the basic components (the building blocks), layout, structure and design details.

### 3.4.3 The Space Client Layout

The visual layout of the space client is shown below in figure x.x.

@TODO Either draw or use screen shot, the former preferably

The space client is made up of three sections namely:

1. The Left Sidebar
2. The Topbar
3. The Whiteboard

The left side bar houses the components toolbox, the chats widget and the connected users listbox. Icons on the toolbox represent various components and when activated by the user (e.g. via a mouse click), the corresponding component is instantiated on the whiteboard.

The topbar houses the remote cursor control and the zoom tools. The remote cursor control is used by the current user to signal to the system that the mouse cursor position should be tracked and displayed to other connected users. This control is a toggle control which means that activating it when the functionality is active turns of the functionality. The zoom controls on the other hand can be used to increase or decrease the scale factor of the whiteboard viewport thereby making the components appear bigger or smaller on the screen. The extreme right side of the topbar also shows the connection status of the application to the server. The connection status can either be ‘Connection failed’, ‘Connected’, or ‘Connection Closed’.

The whiteboard is the main location where components are displayed, interconnected and organised. As previously described, the whiteboard has a much wider size than the available screen size and as such is being viewed through a rectangular frame referred to as a viewport. Hidden portions of the whiteboard can be brought into view by dragging. This is a mouse operation that involves pressing down the mouse button and moving the mouse while holding the button down.

The layout of the interface is achieved by using flex layouts and containers. The three components are flex canvas components and they are laid out using flex group containers. The positioning of the components is carefully done using the system screen coordinates with the origin position (x,y = 0,0) at the upper left corner of the screen. In designing a visual multimedia application, two things are very important; one of them is a simple, easy to use layout with graphically appealing visual components. The other is a carefully designed implementation of the functionalities of these components so as to make it easy for the user to achieve his goals when interacting with the application. In this case, a carefully designed architecture (the MVCS architecture) is employed which is described next.

### 3.4.4 The MVCS Architecture

An architectural pattern helps in decomposing a complex system into simpler ones with “Responsibilities, Relationships and Interactions” (Berkovitz, 2006). An example is the Model, View, Controller, Service (MVCS) architectural pattern. It is employed to achieve a clear separation of responsibilities in the design of the space client. When a system such as this is being designed, it is important that “cohesion” is increased while “coupling” among components is reduced as much as possible. This promotes reusability because the interaction and interdependency among components is greatly reduced. MVCS

@TODO Representational diagram of the MVCS Pattern, with numbered sequence as adapted from Joe

Unpack the diagram.

In a typical flex application, the component ------- presentation, state, actions, communication

The **Model** can be viewed as a data store. Its function is to capture and store the state of the application. The state can be represented as objects, collections, properties, etc. The model also watches the stored data and any change to the state causes it to dispatch events notifying the **View** of such changes. The model does not reference any non-model application component (Berkovitz, 2006).

The **View** handles the presentation and interaction. Presenting the state of the application to the user in its raw form (as objects, arrays, etc) will make no meaning to him so the view bears the responsibility of presenting it in a way that the user can understand and relate with. The user, upon understanding the presentation may choose to interact with it for instance ‘select a picture gallery to view from the list of galleries presented’. The view handles such interaction with the user, however, it does not perform the requested operation for the user, it rather hands over control to the **Controller** by invoking one or more of its operations. Another additional responsibility of the view is to respond to notification of changes in the model (as previously discussed) by updating itself to reflect the current state of the application.

The **Controller** is the coordinator of all activities in the application. As shown on the diagram (@TODO figure xx instead of diagram), it is the only part of the architecture that interacts with all the others. The controller can modify the model when necessary; invoke **Services** when needed and coordinate view-to-view relationships. The controller according to Berkovitz (2006) also “acts as Façade for miscellaneous application logic; progress and error reporting; confirmation, validation; security and authentication. The controller however should not bear the responsibility of communicating with the outside world, this is where the service comes in.

The **Service** bears the responsibility for all remote operations and logic. All communication with the outside world such as Web services, Http calls, Remote Procedure Calls, etc are encapsulated by the service. The service also bears the responsibility of populating the model with remote data.

In order to make it clear how all of this can be applied practically, a brief description of how a component gets created in the space client application is given. The presentation layer of the space client has been described in the space client layout section (@TODO, Link it).When the user elects to instantiate a component (e.g. by clicking its representation icon on the toolbox @TODO, Link Toolbox to description), the presentation layer invokes an operation (addComponent) on the controller. The controller in turn invokes operations on the model that causes the model to initialise default data required by the component. The controller then goes ahead to invoke an operation on the service component (createComponent) passing the initialized model as the single parameter to the operation. The service then goes ahead to make a remote call (add) using the NetConnection and the flash.Net.Responder objects. The NetConnection object establishes the link to the remote server so that the remote call can be invoked while the Responder object handles return values from the server related to the success or failure of the remote operation (@TODO Ref ASDOCs here). If the remote operation is successful, the model is updated and a SYNC (sychronize) event is dispatched which requires the presentation (view) to update its display components. In the case of a new component, it is then instantiated on the client side and displayed on the whiteboard. For a component that already existed, the state is updated to reflect the current state in the model. The diagram below is a visual representation of this process using one of the simple components in the space application.

@TODO draw a graphic showing all that has been described above…..

The MVCS architecture helps structure the different application parts and organize the relationship between them thus resulting in a highly decoupled system that is easily extensible and scalable. A weak link still exists in the architecture however. This weak link is ‘the object creation logic’. In the next section, this is clearly described alongside a solution to it.

## 3.5 Inversion of Control and the SWIZ Framework

In object oriented programming, encapsulation is supposed to hide the internal implementation details of an object from users by separating its interface from its implementation. The data and the implementation code for the object should be hidden behind its interface. However, this is not usually the case when creating objects. Consider the code below:

ConcreteClass ccObject = new ConcreteClass(actual parameters required by constructor)

Obviously, the class creating this object needs to know the actual parameters required to create this object as well as the order in which it is required. Creating objects is therefore considered to be the ‘weak link’ in encapsulation. It can therefore become tricky to decide where (and when) to create objects. The GRASP Creator principle (@TODO Ref Craig Larman) and the Gang of four creational patterns (@TODO Ref Gang of Four) suggest how this might be done for example using the Factory design pattern. One approach to this challenge that has gained popularity over the last few years is the ‘**Inversion of Control**’ strategy.

### 3.5.1 Inversion of Control Strategy

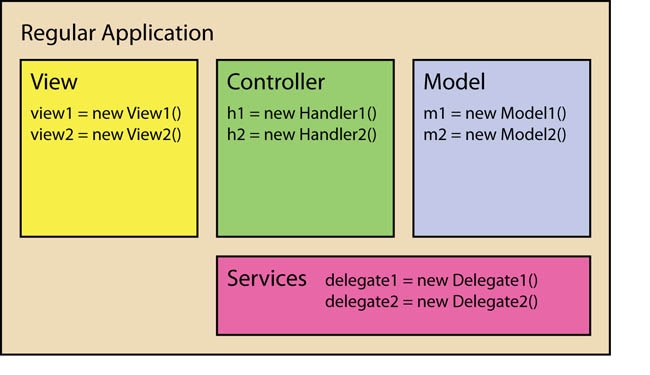
The inversion of control (IOC) design strategy also known as ‘Dependency Injection’ (DI) is “an approach in which a separate object is responsible for populating the fields of other objects with correct implementations, instead of these other objects being responsible themselves” (Eustace, 2009). This approach according to Eustace gives two major benefits:

1. Objects can be decoupled from their implementations by declaring the objects’ fields as interfaces. This is also known as ‘design by contract’.
2. The object creational logic is separated thus making the purpose of the object clearer.

As a follow up on the second benefit, IOC also solves the weak link challenge described earlier thus enabling our MVCS architecture to be fully decoupled as planned. With IOC, the application objects are instantiated in a separate layer and then passed into the application as needed. Sudgen (2009) goes ahead to emphasise the need to decouple the objects of an application “so they can change independently of one another and be tested in isolation”. According to Sudgen, “applying IoC can make it easier to restructure a user interface, substitute the service integration layer, and refactor the models containing the logic and state of your application, amongst other benefits”.

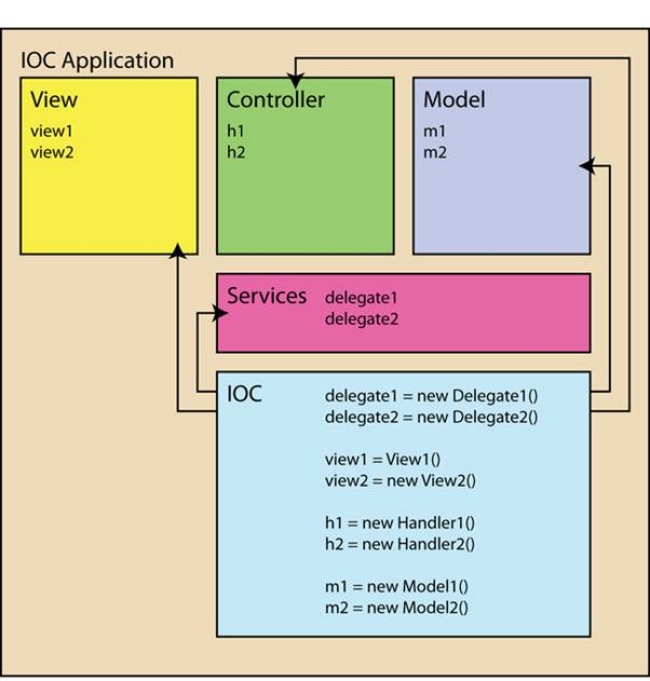
The concept of decoupling the objects of an application can be further explained using an example. The figure below (@TODO figure what?) shows a traditional application architecture and how objects are instantiated.

@TODO traditional instantiation (Re-Draw)



From the figure it can be seen that the architecture is well structured just as described in section 3.4.3 (@TODO verify section and link) using MVCS. However, in creating the objects, the traditional approach is used thus coupling the different layers to each other once again. In order to understand how IOC solves this, the figure below shows an IOC container handling the creational logic as well as the dependency injection logic.

@TODO IOC instantiation, Redraw and state adapted from



In this case, the required objects are defined for each layer but not instantiated at compile time. At runtime, the IOC container instantiates the required objects for each layer and injects them as needed. This is also known as ‘wiring’ the application.

Inversion of control is usually not as easy to implement as described hence the recourse to IOC containers. An IOC container provides a framework for implementing dependency injection in a consistent and declarative way (Eustace, 2009). Examples of such frameworks for Flex include (Eustace, 2009, Sudgen, 2009):

* Spring ActionScript (<http://www.herrodius.com/blog/>)
* Parsley (<http://www.spicefactory.org/>)
* Flicc (<http://flicc.sourceforge.net/>)
* SmartyPants IOC (<http://code.google.com/p/smartypants-ioc/>)
* Swiz (<http://swizframework.org>)

The Swiz framework was used in designing the space client. A brief description of the Swiz framework and how it is applied in the design is discussed next.

### 3.5.2 The SWIZ Framework

Swiz is “a framework for Adobe Flex and ActionScript that aims to bring complete simplicity to RIA development” (Swiz, 2011). It is more than just an IOC framework; it is meant to be a complete solution for Rich Internet Application (RIA) architecture (Eustace, 2009). Swiz provides the following (Swiz, 2011):

* Inversion of Control / Dependency Injection
* Event handing and mediation
* A simple life cycle for asynchronous remote methods
* A framework that is decoupled from the application code

The basic Swiz configuration can be done in three steps

1. Create the beans file
2. Add a SwizConfig to the application and pass in the beans file
3. Add the metadata to the classes into which you want to inject dependencies

@TODO Maybe give example of a Swiz Bean File, a config code and a metadata usage in the Appendices, Use Eustace as base but adapt to Space Application.

Beans in Swiz are MXML (@TODO See Section???) files that extend the Swiz BeanLoader class (Orlando, 2009). The content of a beans file is usually a series of object declarations within the beanloader tags. After loading the Swiz configuration, the objects can be wired to the application either by calling ‘Swiz.getBean (“bean-name”)’ or using ‘metadata’ such as Autowire, Mediate, etc. The Autowire tag is used for component wiring, while the Mediate tag is used for dynamic mediation of events during the bubbling phase of the event life cycle (Orlando, 2009).

In the space client application, the Swiz framework is used to inject the dependencies needed and also mediate some events. Controller objects (e.g. whiteboardController), model objects, view objects and service objects are declared in the Beans.mxml swiz beans file. The *SwizConfig* class is then used to inject the beans file into the application. The table below gives a visual summary of some of the objects managed by the Swiz framework in the space client application.

@TODO Table of Swiz Managed Objects.

So what’s next?

4 System Design – Main Feature

Although several media components were added to the space client, the main or target media component that was required is the Personal Development Planner (PDP). This section discusses the design of the PDP media component in various phases.

4.1 Overview of the Personal Development Planning (PDP) Component

The personal development planner enables the learner to take control of his learning by making concrete plans it. The component is implemented based on the theories of PDP and CPD discussed in section x.x (@TODO which section). After performing a self-audit which is not covered by the component, the learner is prompted to state clearly his learning goals and success criteria. Steps to be taken to achieve them within a specified time frame is also documented. The personal development planner becomes a basis for the learner to construct knowledge based on the documented items. Doing this is as simple as connecting other relevant media components to the PDP component. For example, a learner who wishes to learn how to play the piano might create a PDP component and fill in the necessary data. He will then proceed to search for useful materials that will help him achieve his goal. Assuming he finds a YouTube video, he can then instantiate a video component and link it to the PDP component using one of the edges (directional or otherwise). The edge can be labeled thereby further clarifying the purpose of the linked video. Other components such as links, text, images, etc can be linked to the PDP component thereby resulting in a knowledge artefact that can be (re)used by the learner to achieve the intended goal. A PDP component can also be attached to another PDP component thereby forming a chain of goals and actualisation steps. For example, a PDP component whose goal is ‘Learn to program in PHP’ can be linked to another PDP component whose goal is ‘Learn to develop web applications’. The figure below gives a sketch of a PDP and a screen shot of the implementation.

@TODO Sketch of PDP Component as well as screen shot of it?

4.1.2 Sub Components for the PDP Component

4.1.3 Data Requirements for the PDP Component

The major data required for the PDP component are as follows:

* PDP Goal
* Success criteria
* Target dates
* Steps to be taken
* Status of the process
* Reflection and evaluation notes

The PDP Goal is the main objective of the process. The learner sets a goal for himself and then specifies success criteria to be used to ascertain that the goal has been achieved. An example of a goal and a success criterion is given below:

* **PDP GOAL**: Learn to develop web applications in Rails
* **SUCCESS CRITERION**: I will develop a Couples-Matcher application for the School of Computer Science May Ball, 2012

The target dates include target start date and end date. For learning to be effective, the goals need to be Small, Measureable, A, R, Time bound (SMART). The target dates ensure that the learner does not live perpetually

4.2 Initial Design of PDP

4.2.1 Initial PDP Layout

4.2.2 PDP Sub Components Layout

4.2.3 Connecting Sub Components Via Nodes and Arcs

4.2.4 Improvements to the Initial Design

4.3 Second Design of PDP

4.3.1 Improved Layout for Sub Components

4.3.2 Improved User Interaction

4.3.3 Improvements to the Second Design

4.4 User Experience Design for the PDP

4.5 Test Release

4.5.1 User Trials

4.6 Summary

Initial considerations and Assumptions

Problem Analysis

Design Goals

Spaces Server

Spaces Client

RTMP Connectors

Interface Design

Overall Space Layout

Initial PDP Layout

PDP Without PDP Components

PDP With PDP Components

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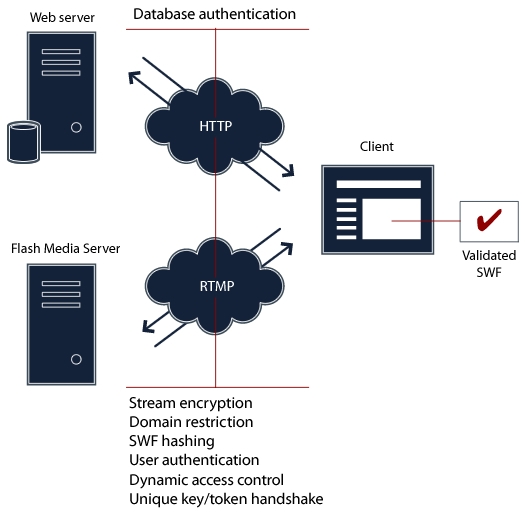
THINK ABOUT IT, MAYBE INCLUDE IT SOMEWHERE:

RTMP AND SECURITY or SECURITY IMPLEMENTATION IN THE SPACES. Scalability too? Maybe

<http://livedocs.adobe.com/flashmediaserver/3.0/docs/help.html?content=04_overview_security_15.html>

<http://www.adobe.com/devnet/flashmediaserver/articles/scaling_securing_fms3.html>

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## 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.

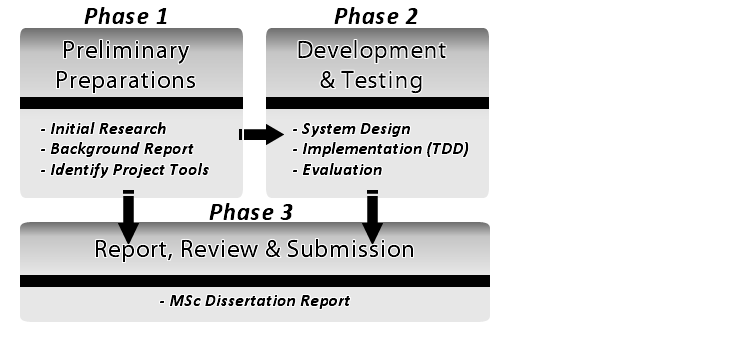


Figure 6 - Research Methodology Flow

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”.

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# Appendix A: Project Plan Gantt Chart

