An IMS Learning Design Meta-Model for Learners with Autism

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A Thesis submitted for the Degree of Master of Science
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June 2008

Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of MSc in Computing, is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abstract

This study investigates the Instructional Management System (IMS) Learning Design (LD) specification (IMS-LD), which was originally published by experts in the Open University of the Netherlands (OUNL). Our project aims to produce an IMS meta-model, which can provide for special learning styles, and satisfy learners' special needs during the learning process. Our research has produced an IMS lesson or Unit of Learning (UoL) to support learners with autism. Young learners with autism have special learning needs and characteristics that educational software must respond to. Certain IMS-LD features (Property and Condition) and services (for example, Monitoring) have been adopted to enhance a suitable dynamic learning design. The IMS-LD uses XHTML technology to develop an appropriate learning interface and content.

IMS-LD based open source software tools have already been developed by members of research projects, e.g., Alfanet, UNFOLD and Developing for Learning Design (D4LD), in the recent decade. The present investigation has used some of these software tools to develop the online learning material.

The IMS-LD based prototypes have been analysed, designed and implemented to help investigate the potential of this recent specification, the IMS Learning Design. Web technologies have been adopted in the prototypes, e.g., Cascading Style Sheets (CSS) and JavaScript. Further web technologies are used also to enhance learning effectiveness, e.g., Flash and audio.

A software-based 'learning scenario' was designed, developed and then evaluated by an expert user group. Data was collected and analysed, and results indicate that the IMS-LD lessons could be suitable for learners with special needs and autism. The prototype lessons provide individual learning with personal learning interfaces and materials.

This investigation is a novel one, as the IMS Learning Design specification is not yet widely adopted in the eLearning industry. Our study indicates some advantages and disadvantages, in applying its meta-model approach, in special education software design.

Acknowledgements

I would like to express my gratitude to all those who gave me the possibility to complete this thesis. I also would like to thank the kind assistance and support of the following individuals and groups:

- My supervisor Mrs. Mary Barry, who gave me great suggestions and encouragement throughout the research, and Mrs. Jacinta Byrne-Doran, who provided valuable insights and advice to this project.
- The Expert User Group – for their time and helpful feedback during my project evaluation sessions.
- Head of Department and WIT staff in the Department of Computing, Mathematics and Physics – for their support.
- WeLearnT eLearning Technologies research group – for all of their expert assistance.
- Research Support Unit and International Office – providing guidelines and assistance, and for their support in my travel and visa requirements.
- The Institutes of Technology Ireland (IoTI), Council of Directors – This investigation has been funded by the TSR STRAND 1 Postgraduate R&D Skills Programme.
- My colleagues, Rosanne and Leanne, and all my friends in the library postgraduate research area.

  - My esteemed parents, and my family, for your belief in me and love.
    感谢我敬爱的父母, 和我的家人, 为你们的期望和爱.
  - My girl friend Jie Liu, and all of my friends in Ireland and China.
    感谢我的女朋友, 刘洁, 和我所有爱尔兰和中国的朋友们.

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List of Abbreviations

ABA	Applied Behaviour Analysis
ADL	Advanced Distributed Learning
APA	American Psychiatric Association
ASD	Autism Spectrum Disorders
BPIG	Best Practice and Implementation Guide
CMS	Course Management System
CSS	Cascading Style Sheets
DTD	Document Type Definition
EML	Educational Modelling Language
GUI	Graphical User Interface
HTML	HyperText Mark-up Language
ICD	International statistical Classification of Diseases
IMS	Instructional Management System
IMS/GLC	IMS Global Learning Consortium Inc.
IMS-CP	IMS Content Packaging specification
IMS-LD	IMS Learning Design specification
IMS-LIP	IMS Learner Information Package specification
IMS-QTI	IMS Question and Test Interoperability specification
JISC	Joint Information Systems Committee
LD	Learning Design
LO	Learning Object
NAS	National Autistic Society
OUNL	Open University of the Netherlands
RELOAD	Reusable eLearning Object Authoring & Delivery
SCORM	Sharable Content Object Reference Model
SEN	Special Education Needs
SLeD	Service-based Learning Design
SPSS	Statistical Package for the Social Sciences
SWF	ShockWave Flash
ToM	Theory-of-Mind theory
UKOU	UK Open University
UoL	Unit of Learning
W3C	World Wide Web Consortium
WAV	Windows Audio
WHO	World Health Organization
X4L	eXchange for Learning
XHTML	eXtensible HyperText Mark-up Language
XML	eXtensible Mark-up Language
XSD	XML Schema Definition
XSLT	XML Stylesheet Language Transformation

1. Chapter one: Introduction

1.1 Introduction

This study focuses on investigating and researching the IMS Learning Design Specification (IMS-LD), to develop meta-model driven software used for special needs and learners with autism. The project is concerned with two main fields of research, i.e., special education and computing. This project aims to combine those two disciplines to provide pedagogical web-based software. The development ideas come from the IMS Learning Design Specification (IMS-LD, 2003), which includes features such as reusable software, and support for personalisation. This IMS Learning Design (IMS-LD) meta-model approach will also have to be appropriate to the special needs of learners with autism.

The IMS Learning Design (IMS-LD, 2003) specification was established and developed by educational experts who work in the Open University of the Netherlands (OUNL). Its principles came from the Educational Modelling Language (EML) which built upon eXtensible Mark-up Language (XML).

The word autism appeared in the seminal work of Leo Kanner in 1943 (Hanbury, 2005). For over sixty years, the study of autism has made progress in its educational approaches. In particular, pedagogical experts have created approaches to help those with Autism Spectrum Disorders (ASD) to learn (Howlin, 2002).

1.2 Aims

This project aims to develop an IMS-LD based meta-model to satisfy the special needs of young learners with autism. The educational software end-product generated from the meta-model should provide an online learning approach that develops learning material for learners with autism. The project aims to apply up-to-date online learning technology standards, to the context of learning, for students with autism.

The researcher has listed two research questions, in order to set up a research goal. These are:

1. Does the IMS-LD (Level B) suit the development of learning material for the special needs context of autism?
2. What are the instructional principles and design ideas to adopt in support of the learning process for the child with autism?

1.3 Research Objectives

The following are the research objectives for this study:

- To develop a suitable pedagogical meta-model, and use this model to provide additional descriptions for learning objectives, to make educational software more acceptable and effective for the special needs ASD user (Hanbury, 2005).
- To create an IMS-LD Unit of Learning (UoL) as a software learning scenario, based on the pedagogical meta-model, to support the special needs of these ASD users.
- To evaluate the meta-model and software UoL; to disseminate results after evaluating the feedback; to re-test the software prototype, and also redesign if necessary.

1.4 Chapter Outlines

There follows an outline of the thesis document. These chapters record the research sequences and experimental steps of this research project. The chapters are outlined as follows:

Chapter 1: *Introduction*. This chapter introduces the general research rationale, and the research objectives. The research questions have been provided to indicate the goal of this research project.

Chapter 2: *Literature Review*. The background information on the IMS Learning Design specification (IMS-LD) and Autism Spectrum Disorders (ASD) has been investigated. It also includes the context of special education strategies and supporting web technologies for use in prototype lessons.

Chapter 3: *Analysis of Research Context*. Research aspects have been analysed, for example, the learner's learning styles and IMS-LD specification. The IMS-LD meta-model has been analysed as a basis for use in the next stage, i.e., development of the prototype lessons.

Chapter 4: *Meta-model and UoL Design*. This chapter describes the design and implementation of an actual IMS-LD Unit of Learning (UoL) package that contains and supports the prototype lessons.

Chapter 5: *Evaluation*. An expert user group, experienced in using and working with online learning courses, has evaluated the IMS-LD based prototypes. Feedback is collected and analysed in this chapter.

Chapter 6: *Conclusion*. The findings in this research project are discussed, and some conclusions are drawn on the current status of the IMS-LD specification. Ideas on future development are proposed.

2. Chapter Two: Literature Review

2.1 Introduction

This project aims to investigate an innovative approach to the design of educational software suited to learners with special needs. The title of this project is ‘An IMS Learning Design Meta-model for Learners with Autism’, based on the IMS Learning Design specification (IMS/GLC, 2008; IMS-LD, 2003). The review of the literature is therefore divided into three sections as follows:

- IMS Learning Design specification (IMS-LD)
- Autism and Special Education
- IMS-LD Software Development, in the Learning Management System.

The literature review includes the theories and principles for online computer-based learning and relevant e-Learning software tools. The document also examines the current pedagogical techniques for special education relating to the Autism Spectrum Disorders (ASD).

2.2 IMS Learning Design

2.2.1 *Background*

The original Instructional Management System (IMS) was a project that was created by American organisations and institutes. One of the most important contributors was the non-profit association called Educom, which began initial work with IMS first in 1996 (Heterick, 1998). The IMS Global Learning Consortium (IMS/GLC, 2008) has developed specifications for learning processes in the online environment. They have set up the Learning Design Working Group (Olivier and Tattersall, 2005).

Also started in 1997, the Open University of the Netherlands (OUNL) had an R&D program on learning technology. It is called the Educational Modelling Language (EML) (Olivier and Tattersall, 2005). Koper was the leader in this project. Koper and his team had been involved in the development of EML and had become major contributors to the IMS Learning Design Working Group (Britain, 2004). The EML was submitted to this group in the second quarter of 2001, and then it was accepted as the basis for the Learning Design specification in August 2001. Finally, the IMS/GLC and the OUNL chose the name for their group after the first meeting, called 'The Valkenburg Group'.

After two years' exploring, the researchers of the Valkenburg Group released the first version of IMS Learning Design 1.0 specification (IMS-LD) in February 2003 (Olivier and Tattersall, 2005; Koper and Olivier, 2004; IMS-LD, 2003). It was an extension of EML. From that time, they gradually published their updated versions' specifications. Also, new IMS specifications were developed to support these learning design principles and learning activity processes. There were some new specifications published in the following years, for example, IMS Content Packaging Specification (IMS-CP, 2005), IMS Question and Test Interoperability Specification (IMS-QTI, 2006), and the IMS Learner Information Package Specification (IMS-LIP, 2005). These specifications can combine and work together to provide a complete learning environment for learners.

From 2003 up to now, many countries and different educational institutes have focused on electronic learning. There also were many e-Learning projects funded by organisations and web-based companies (Koper, 2005b). Pedagogical software tools were developed to suit the existing IMS Learning Design specification. For example, in the UK, the Joint Information Systems Committee (JISC) was established under the Higher Education Funding Council (JISC, 2008). It has provided the funded project to develop the Service-based Learning Design (SLeD) Player, to offer a running platform for e-Learning courses based on IMS-LD (SLeD, 2005).

The OUNL group completed a project (UNFOLD) in May of 2006. The UNFOLD project was focused on the IMS-LD and supported the adoption of open e-Learning standards for multiple learners and flexible pedagogies (UNFOLD, 2006; Griffiths, 2005). Later, they started a new project, called ‘TENCompetence’ (TENCompetence, 2008; Koper, 2005). It is a project relevant to the learning network and individual learner. These ‘learning networks’ support lifelong competency development.

The researchers of IMS/GLC and OUNL are moving the IMS-LD into the next stage in their research goal, which is focused on collaborative learning in a learning network (Koper, 2006). It is also an ongoing goal to disseminate the IMS-LD specification to be widely used by educators and to facilitate online learning in the future.

2.2.2 *Educational Modelling Language*

The Educational Modelling Language (EML) was an idea that evolved in the Open University of the Netherlands (OUNL) so that they could move all courses online. It is a complete model for online learning principles (EML, 2000). The EML’s initial goal was to create models of key pedagogical approaches, in the OUNL (Griffiths, 2005). The IMS-LD was developed, based on the EML and took its main principles from EML (Janssen and Hermans, 2005).

EML is a notational system to provide a way of describing teaching and learning interactions at a level of abstraction using meta-data to describe learning content (Britain, 2004). It was intended to encapsulate all teaching and learning interactions. The EML includes all types of learning activities to provide a whole lesson scenario.

To compare the EML and IMS-LD, they shared a common philosophy (Tattersall and Koper, 2003), i.e., both using the notational language to describe the learning process. But also they have their dissimilarities, i.e., EML is a single approach to developing learning experiences; IMS-LD is a framework, integrated with other IMS specifications.

The EML had developed its own software tool ‘Edubox’, and it was used within the OUNL (Koper, 2006). Since 2003, the researchers of OUNL have focused on the IMS-LD and LD tools, and they have joined with the IMS, so that the EML is no longer maintained or updated.

2.2.3 *Unit of Learning (UoL)*

As defined by Olivier and Tattersall (2005), the Unit of Learning (UoL) is a learning scenario or lesson. It is the smallest learning activity to deliver the learning objective to learners. The UoL can be seen as a general lesson that can be instantiated and reused many times for different users and settings, in any online environment. That means the UoL can be used to represent the pedagogical model for the Learning Design.

2.2.4 *Learning Design*

A ‘learning design’ is defined here as an application of a pedagogical model for a specific learning objective, to a target group and in a specific context or knowledge domain (Koper and Olivier, 2004). A learning design is also defined as the description of the teaching-learning process that takes place in the Unit of Learning (Koper, 2005a). The learning design represents the learning activities that are to be performed by different persons, then packaged with the content of a UoL. The UoL also contains the physical files and learning services required (McAndrew and Weller, 2005).

2.2.5 *IMS Learning Design Specification (IMS-LD)*

Since the publication of the IMS Learning Design specification in February 2003 by the Open University of the Netherlands (IMS-LD, 2003), it aims to represent the learning design of the Unit of Learning (UoL) in a semantic, formal and machine interpretable way (Koper, 2005b; Koper and Olivier, 2004). The IMS-LD is a standardised learning design language that was based on the work of EML at the OUNL.

The IMS has developed a set of document types for its specifications. There are three documents: an Information Model, a Best Practice and Implementation Guide (BPIG) and an eXtensible Mark-up Language (XML) Binding document (IMS/GLC, 2008; Olivier and Tattersall, 2005). These documents provide the rules for designers who want to develop the LD according to the IMS Learning Design specification. They also provide benefits and advantages for end-users as follows (Koper and Olivier, 2004):

- Completeness: The specification describes the activities both of learners and staff in the teaching-learning process. The IMS-LD also supports a single and multiple user model of learning. It integrates resources and services within the environment.

- Pedagogical expressiveness: The specification describes different ways to express the learning objective to learners, e.g., problem-based learning.
- Personalisation: The design of personalisation in LD is supported through the ‘Conditions’ and ‘Property’ mechanisms. Personal characteristics can be measured and stored in Properties.
- Compatibility: LD acts as an integration framework for other specifications that are needed to specify an e-Learning course. For example, the different IMS specifications can be used in one course, e.g., IMS Question and Test Interoperability (IMS-QTI), and IMS Learner Information Package (IMS-LIP).
- Reusability: With LD, reusability can be defined at different levels of reuse, ranging from whole units of learning, through learning designs and learning methods, to learning activities, learning objects and learning services.
- Formalisation: EML and IMS-LD provide a semantic specification, i.e. the names and structures are chosen in such a way that they can be understood by human beings (as opposed to computers).
- Reproducibility: The LD specification does not contain any information about specific groups, details, dates or service facilities that would bind a design to a specific context - this kind of information needs to be supplied when a design is instantiated.

Those advantages are benefits for designers who use the IMS-LD to develop their online learning course. In the following section, there are details of other aspects of IMS-LD.

Constitution of IMS-LD

The following quote from Koper and Olivier (2004) describes the constitution of the IMS-LD:

> ‘The LD specification, following common IMS practice, consists of:
>
> (a) A conceptual model that defines the basic concepts and relations in a LD
>
> (b) An information model that describes the elements and attributes through which an LD can be specified in a precise way
>
> (c) A series of XML Schema Definition (XSD) in which the information model is implemented (the ‘binding’)
>
> (d) A Best Practice and Implementation Guide (BPIG)
>
> (e) A binding document and example XML document instances that express a set of learning requirement scenarios.’

It is a complex framework. The main operational parts, for the designer, are the IMS-LD Level A, B and C, which are described next.

Learning Design Architecture

As seen in *Figure 2-1*, the Learning Design Architecture has been illustrated by Olivier and Tattersall (2005). A learning design runs in the IMS-LD environment, as a Play, similar to a theatrical play, consisting of Acts. An Act includes Role-parts (e.g., learner and Special Education Needs tutor). A Role-part is used to assign an Activity to a Role, and to render the Activity. A method then binds Acts and Role-parts together in preparation for a learning scenario (Olivier and Tattersall, 2005).

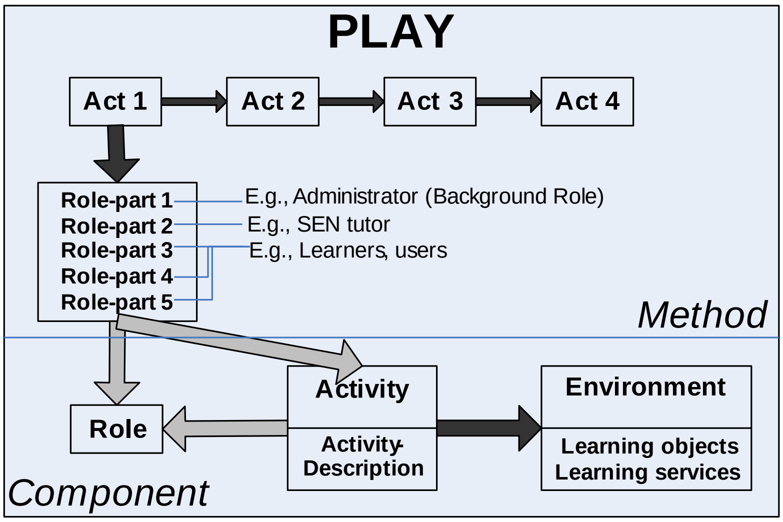

Figure 2-1: Learning Design Architecture (redrawn from Halm *et al.*, 2005)

The IMS-LD component draws it all together (Role, Activity Environment) to provide the learning scenario.

IMS-LD Three Levels

To achieve the IMS-LD specification's goal, the specification is divided into three levels to map to separate XML schemas (IMS-LD, 2003). Therefore, each level has a different purpose within a learning design. The three levels include:

Level A which contains the core vocabulary needed to support pedagogical diversity (IMS-LD, 2003). It is focused on the learning flow and it describes the outline for the learning objectives and learning methods. Level A describes the simple Unit of Learning (UoL) within the XML binding document.

Level B also uses the XML document to encode its UoLs. It can be considered that it is based on Level A, but can contain more details (IMS-LD, 2003). The details are based on two main aspects.

The first aspect is the Property feature (Koper and Burgos, 2005; Olivier and Tattersall, 2005). The internal Property can provide a limit and control on the learning flow events. Also it can provide more information stored in LD for the Roles and Learning Object (LO). The Role represents the person who is involved in the LD, e.g., a group of learners or an individual learner (for example with autism). The Property is used for storing the vocabulary and containing information to focus on the global output. For example, a global personal Property holds information about user ID, surname and first name.

The other aspect is the Condition feature (Koper and Burgos, 2005; Olivier and Tattersall, 2005). The Condition is used to offer more options to the Roles, to make the LD product have more diversity, and a variety of LD content. Level B has these additional concepts and associated capabilities in order to support more sophisticated behaviours for the LD. It also has the opportunity to analyse the end user details, for example, is the assessment question answered correctly in the last learning activity? These features can be further explored in a practical example later in this document.

Level C. Similar to previous levels, Level C provides its output in XML Binding format. It is also based on Level B, but it has more notification features (IMS-LD, 2003). It provides a greater level of interactivity and control over a live learning design, in the form of an event-driven messaging system within an LD Player (Olivier and Tattersall, 2005). For example, Level C can offer a message between system components and between the Roles. Also the activities can be changed during run-time using a dynamic learner profile. It can also be event-driven, e.g., using the IMS Learner Information Package (IMS-LIP) to control activities.

Level C offers the possibility to design a network of event rules rather than a pre-planned order of events (IMS-LD, 2003). The challenge at this level is that it has high processing needs, such as learners' profiles to be maintained, security information to be assured, and network communication problems to be supported (Koper, 2006).

In summary, for this project the Level B features offer the flexibility needed to experiment with Properties and Conditions so that learning scenarios can be customised for learners with special needs.

Positioning and Navigation Services

Within the new theory of IMS Learning Design specification (IMS-LD) (Kalz *et al.*, 2007), the IMS-LD has developed new services related to adult learners during the experiments in the OUNL. They are the positioning and navigation, as services that support learners. The positioning service analyses the prior learning of learners through a content analysis method while the navigation service recommends the next best learning activity for a student.

2.2.6 *Property and Condition Features in IMS-LD*

In this section, we describe the Property feature and Condition Feature of IMS-LD Level B in use.

Property Feature Definition

The Property is a feature of the IMS Learning Design specification (IMS-LD) Level B (IMS-LD, 2003). It stores information during the learning process, and provides more effective learning content. As defined in the IMS-LD specification (2003): ‘Properties form the basis on which to build user and role dossiers and portfolios’. Therefore the Property provides services such as monitoring, personalisation, assessment, and user-interaction. There are five types of Properties defined in the specification.

Five Types of Properties

The five types of Properties (IMS-LD, 2003) are:

- Global Properties (XML element name: glob-property)
- Global Personal Properties (XML element name: globpers-property)
- Local Properties (XML element name: loc-property)
- Local Personal Properties (XML element name: locpers-property)
- Local Role Properties (XML element name: locrole-property).

In this research, we experiment with these Properties to support special needs learning. The different Properties have their own element names that are used in the IMS Manifest file (imsmanifest.xml) in the IMS Learning Design document. The **Element Name** distinguishes the Properties in XML code (Koper and Miao, 2007). Element names can be interrogated at run-time to display Property values.

Condition Feature Definition

The Condition is the second feature, which the IMS Learning Design specification (IMS-LD) Level B provides, and which is explored in the present investigation. According to the definition in the IMS-LD specification (2003), 'Conditions are used in conjunction with Properties to add further refinement and personalisation facilities in the learning design'.

Therefore, the Condition feature could provide the personalisation for an individual learner in the learning design. Furthermore, it also could improve the learning activities that support special learning styles. The Condition feature is investigated as a design idea for this research project.

The Format of a Condition

As defined in the IMS-LD specification (2003), the Condition feature adopts the basic format as follows:

If [expression]-Then [show, hide, or change something]-(Else [])

Within the IMS Manifest file, this format is used to control and trigger an event (learning activity). The pre-Condition value is defined at design time and needs to be evaluated at run-time. Each time a Condition is evaluated the relevant Property may change accordingly, thus offering control over learning activities and progression.

2.2.7 *IMS-LD Summary*

To summarise, the IMS-LD is used for instructional online material and activities. The present research investigation adopts the features (Property and Condition) of IMS-LD Level B to cater for learners' special needs, and to develop an IMS learning meta-model. In the following section, there is an introduction to autism.

2.3 Autism and Special Education

2.3.1 *Introduction*

It is reported that there are 70 children with autism per 10,000 children, although, this prevalence keeps growing (Hanbury, 2005). Researchers have already made progress in recent decades and have documented their experiments and theories on autism and its treatment.

In 1943, there appeared the word 'autism' for the first time in the seminal work of Kanner (1943). In the following year, another doctor, Asperger published the word 'Autistic' (Adams *et al.*, 2002). Those two scientists researched and developed the field concerning this group of children (and adults) with special needs.

Creak (1964) led a working party, which defined nine key features. Creak's research provided for more features than did Kanner's research. It also represented the first attempts at a systemised method for diagnoses. Rimland's work (Rimland *et al.*, 1978), based on studies from 1964, has shown that autism is a biological disorder and not an emotional illness.

In 1980, the American Psychiatric Association (APA) published the third edition of Diagnostic and Statistical Manual of Mental Disorder, know as DSM III. The most recent version is DSM-IV, published in June 2000 (APA, 2008). The other system of classification used by many clinicians is the World Health Organization's (WHO, 2007) International Statistical Classification of Diseases and Related Health Problem, the 1992 edition being known as ICD-10. These two publications were important contributions for diagnosing Autism.

2.3.2 *Three Psychological Theories of Autism*

As the science and techniques were developed, some current psychological theories of autism have been proposed and explored by researchers. Researchers focusing on the learner's learning disability have proposed the following three main theories: Theory-of-Mind (ToM) theory, Central Coherence (CC) theory, and Executive Function (EF) theory. According to Baron-Cohen and Swettenham (1997), 'these emerged as important domains over the last decade of psychological research in autism'.

Theory-of-Mind Theory (ToM)

The Theory-of-Mind (ToM) theory has been explored by Baron-Cohen. The ToM theory explains the social and communication impairments of children with autism (Baron-Cohen, 1995).

He has found that autistic children do not seem to engage in pretend or symbolic play (Baron-Cohen, 1987), and therefore have poor performance on false belief tasks. Within Baron-Cohen's theory, there are different tests for people with autism, for example, a test of imagination, a test of poor use of pragmatics, a test of difficulty in understanding complex causes of emotion, and a test about the inability to deceive.

Central Coherence Theory (CC)

The Central Coherence theory (CC) is used to focus on a particular feature of autism. According to Frith and Happé (1994), there are three aspects to this theory:

1. Perceptual coherence
2. Visuospatial constructional coherence
3. Verbal-semantic coherence.

Happé (2005) indicates that ‘Weak central coherence predicts relatively good performance where attention to local information (i.e., relatively piecemeal processing) is advantageous, but poor performance on tasks requiring the recognition of global meaning or integration of stimuli in context’.

Central coherence describes the ability to process incoming information in context, pulling information together for higher-level meaning (Pellicano *et al.*, 2005; Happé, 1999).

Executive Function Theory (EF)

The Executive Function (EF) theory is defined by Shallice (1988) as follows: ‘it is the postulated mechanism which enables the normal person to shift attention flexibly, inhibit proponent responses, generate goal-directed behaviour, and solve problems in a planful, strategic way’. It therefore underpins a lack of ability in planning one’s activities and carrying out everyday tasks, since Executive Function is weak in persons with autism.

According to Frye *et al*. (1995), Executive dysfunction cannot explain autism by itself. In particular, advances in understanding Executive Functioning (EF) show it to be bound up with ToM development. The feature of executive dysfunction has usually appeared in children with autism, but it has also appeared in other syndromes, such as schizophrenia or obsessive-compulsive disorder.

These three theories are the main theories used for describing people with autism.

2.3.3 *Autism Learning Context*

According to the experts, children with autism may have a variety of responses while learning (Hanbury, 2005; Goodlin-Jones and Solomon, 2003). These may include anger, fear, anxiety and obsession. The educator must devise strategies to support the learner and gradually help him or her to make progress. As communication improves (Moor, 2002) the learner’s attention is gradually engaged so learning can take place.

2.3.4 *Attributes of Learning Styles*

Children with autism have special learning styles that differ from normally developing children. Their language skills and especially their communication skills need extra support (Goodlin-Jones and Solomon, 2003). The following are attributes that educators needs to consider:

- Attention: Within the learning process, the learner could lose attention and have difficulty following the learning process.
- Language Skills: Learners with autism may misunderstand the meaning of certain words, and they have difficulty with symbols and symbolic meaning (Moor, 2002).
- Perception and Cognition: Learners with autism may understand the word, but not know what it means (Powell, 2000). For example, the children with autism can remember a book or film, but they have difficulty in getting the feeling and sentiment from that book or film.
- Interest and Motivation: Learners with autism may have a hobby, but may be very focused on a narrow set of interests. Also it may be difficult to keep them motivated to learn new things (Hanbury, 2005).
- Communication skills: Learners with autism have difficulty communicating with other people. But, it does not mean that they do not have the ability for learning (Siegel, 2003).
- Emotion: The learner with autism may be more easily scared in new situations than the normally developing child (Hanbury, 2005).

Special education strategies are reviewed in the following section.

2.3.5 *Special Education*

In this section, some literature related to special education for learners with Autism will be reviewed. The strategies of special education deal with how autistic learners benefit more effectively from their environment and the learning-teaching structure (Siegel, 2003; Auxter *et al.*, 2001).

The keys to success are sound knowledge, hard work and appropriate resources (Hanbury, 2005). A common strategy also is evaluation. It means that strategies have to be used and evaluated to assess the effectiveness of practices, through regular reviews of the child's learning progress.

Three Key Approaches

According to Durig (2005), three key approaches can provide the autistic learner with a peaceful environment for learning. These are:

1. Maintaining a calm environment.
2. Each learner with autism has his or her own personality, so prepare for individual practice.
3. Reflect on their perception: To build a course for learners with autism, the designer needs to design and plan the course from the learner's point of view.

2.3.6 *The Learner's Perspective*

Education in autism needs to be pursued from the child's perspective (Powell, 2000). To teach the child we have to consider doing it in the child's way. The learning designer develops a curriculum for them. They may be too young to understand the point (Learning Objectives) to be learned, the content might not have enough learning meaning, or the software interface may not be attractive to the young learners so they may not focus on it (NAS, 2008; Siegel, 2003).

According to Powell (2000), the question is not ‘How can I motivate the children to learn?’ any more. Instead it is ‘How can I help the child to be motivated?’. In practice, the designer should include software features to stimulate the learner’s motivation. For example, educational software should offer some optional choice and rewards to the child with autism, during the learning process. This needs to be taken into consideration when an IMS-LD Unit of Learning (UoL) is designed.

Powell points out that meaning is central to our socially constructed way of living. Objects and events have meaning or are given meaning and this enables us to manage our work and learning within it (Powell, 2000). There is a ‘system’ to accompany us while growing up, a complete system in a person’s mind. However the children with autism have not got this system, or the input information and output information is distorted, so that they do not have correct responses. In order to solve this problem, different teaching and learning approaches, for example, Applied Behaviour Analysis (ABA, 2006) use particular mechanisms or teaching techniques in special education.

The Lack of Use of Meaning

Before designers choose any educational strategies to support the learners with autism, they have to consider the learner’s learning behaviours. As Powell defined (2000), there are implications of the lack of use of meaning, when comparing learners with autism with normally developing learners.

1. Reliance on memory by rote: It means that nothing makes sense because understandings of purposes, functions, roles and time constrains have not been learnt.

2. Difficulties with prediction: The child with autism may have difficulty knowing what comes next.
3. Difficulties in making connections: It is the meaningfulness of things that enables us to make connections between different events, but this may be difficult for the learner with autism.

According to Powell (2000), these difficulties are evident during the learning process of the learner with autism. Summarizing these difficulties, it can be seen that the learning process needs to be perceptually based so that meaning becomes easier to perceive for these learners.

2.3.7 *Teaching Approaches*

During many years of research by special education experts, methodologies have been developed for use with learners with autism. Fifty percent of parents report features of autism in their children by 2 years of age and 93 percent indicate recognition of symptoms by age 3 (Matson *et al.*, 2007). According to Hanbury (2005), there is also the challenge of engaging in a comprehensive programme which responds to the child's learning profile. It can confirm the learning purpose and perspectives. Also which method will be adopted and used to suit the child with autism, needs to be assessed.

The interventions and approaches are used for selecting the programme for the child with autism. For example, according to Taylor (2005), the learner with autism has difficulty with group learning. Instead it is better to provide individual learning. Therefore, the learner needs an individual special educational strategy for his or her learning process. In the following section, some existing methodologies for learners with autism are documented.

TEACCH

TEACCH (2006) is an acronym for Treatment and Education of Autistic and Related Communication-Handicapped Children. It is a curriculum developed at the University of North Carolina, USA. It was developed and spear-headed by Dr. Eric Schopler (TEACCH, 2006; Siegel, 2003). The main approach of TEACCH is to achieve an appropriate structure in teaching and encourage self-initiative in learners with autism.

ABA Training

Applied Behaviour Analysis (ABA) originated in the University of Kansas (Baer *et al.*, 1968). It is also called Lovaas Training (ABA, 2006). It is based on clinical experience and research carried out over more than 30 years by the psychologist Dr. Lovaas, in the USA (NAS, 2008).

In the late 60s and 70s Lovaas worked with institutionalised, non-verbal children who had been diagnosed as autistic. He defined ABA as a science that seeks to use empirically validated behaviour change procedures, for assisting individuals in developing skills with social value (Lovaas, 1997). The ABA therapy concentrates on verbal communication in the training of learners with autism.

According to Moor (2002), ABA training is one of the long-standing therapies that has a central theme of structure, which has proved positive for children with autism. The best age to begin intensive ABA therapy is before three and half years of age, and the duration of ABA therapy is between 24-48 months. The learners with autism have to engage in many practices that seek to train them to respond in ABA training.

SPELL

SPELL stands for Structure Positive approaches and expectations Empathy Low arousal Links (NAS, 2008). The SPELL framework has been developed by the UK National Autistic Society's schools. It is a service to help understand and respond to the special needs of children and adults with autism. It aims to recognise the unique needs of each child and emphasizes that all intervention and planning should be organised as follows:

- Structure makes the pupils with autism learn in a more predictable, accessible and safer place, and also can aid personal autonomy and independence.
- Positive approaches and expectations seek to establish and reinforce self-confidence and self-esteem by building on natural strengths, interest and abilities.
- Empathy is essential to underpin any approach designed to develop communication and reduce anxiety.
- The approaches and environment need to be low arousal: i.e., be calm and ordered in such a way as to reduce anxiety and aid concentration.
- Strong links between the therapeutic programme and various components of the person’s life will promote and sustain essential consistency.

PECS

The Picture Exchange Communication System (PECS) methodology is a communication system to treat children with autism. PECS provides pictures and photographs to assist the child's communicative effort. It is good to use in the early stage of teaching (Howlin, 2002).

PECS is a non-verbal system which is adopted in special education classes. The child with autism shows and exchanges the pictures on the board to indicate to tutors what objects he or she wants. As the creators hoped (Bondy and Frost, 1996), the system can help many children to calmly and clearly make a request, in school or at home.

Musical Interaction

The principle of Musical Interaction had first been explored by Alvin (1975), as one component of a wider educational curriculum for learners with autism. The musical interaction sessions (Prevezer, 2000; Alvin and Warwick, 1991) are about facilitating the development of communication skills in a social context. The sound sensitivity can be used to block or distract from other events or sensitivities, and actually help people with autism to become calm and to concentrate (Moor, 2002).

Minimal Speech Approach and Play-Drama Intervention

The 'play' approach aims to offer a suitable method for learners with autism, in order to assist with their poor response to spoken language. This improves their communication skills (Potter and Whittaker, 2002; Lord and Paul, 1997). The participant also can understand and learn from speech or drama scenarios.

Computerised Systems

According to Howlin (2002) with the ever-increasing range of computerised devices, for example, the joy stick and touch screen, many learners with autism can use a computer to learn. The learners often enjoy interaction with technology. Also, as Durig suggested (2005), learners with autism may accept instruction from the computer better than from a person. Their computer perception is the same as that of the normally developing child's computer perception (Durig, 2005). From this point of view, learners with autism may accept the computer lessons with ease. In particular, the child with Asperger Syndrome (NAS, 2008) is talented and may enjoy using a computer.

2.3.8 *Summary of Special Needs*

To summarise about learners with autism, this syndrome has not yet been researched completely, but the results show that these children have the ability to learn. Also training in normal skills can enhance their ability to join in the society as well.

2.4 The IMS-LD Development Environment

2.4.1 *Introduction*

In this section we outline techniques to support the design of learning material using the IMS Learning Design specification (IMS-LD). Included also are the typical IMS-LD software tools.

2.4.2 *XML and Document Type Definitions (DTDs)*

IMS-LD is a notation system for learning and instruction (Olivier and Tattersall, 2005; IMS-LD, 2003). The UoL Package of the IMS-LD represents a fixed version of a UoL, including learning objects and services. It contains the XML document within the zipped file exported from the LD Editor. Using IMS-LD, a teaching-learning process is modelled in XML format, which according to Koper and Miao (2007), is a platform-independent web-standard notation for describing arbitrary structured data.

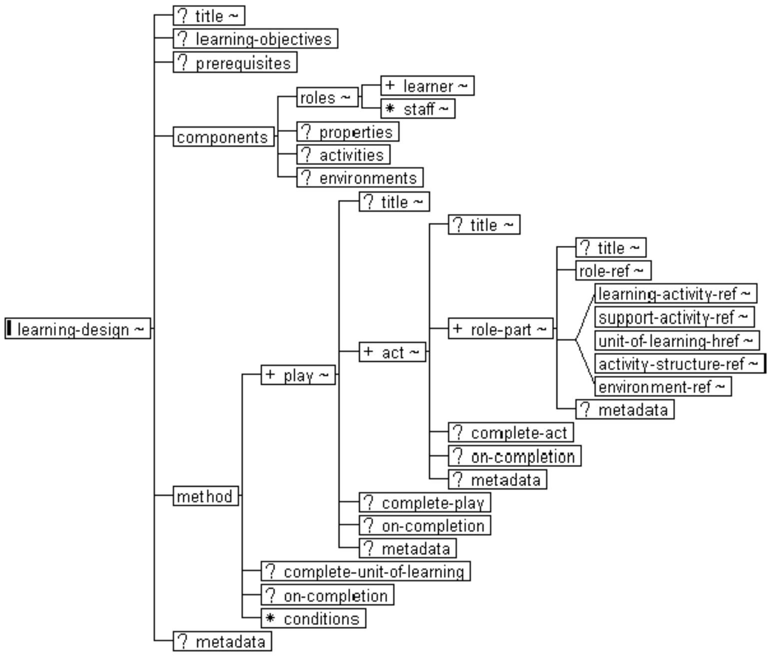

Figure 2-2: IMS-LD Level A XML Schema (Reproduced from Koper and Olivier, 2004)

For example, The IMS-LD Level A XML Schema is represented as a tree, in *Figure 2-2*, and shows that the structure adopted is appropriate for XML type notation (Koper and Bennett, 2006).

XML is a notation language which was created by the World Wide Web Consortium (W3C, 2008) in 1994. The Document Type Definition (DTD) can define the XML document's structure, i.e., what elements and attributes are permitted in the document. It is used to ensure document conformity, and to produce a well-formed and valid XML document.

2.4.3 *IMS-LD Software Tools*

According to Britain (2004), the LD software tools divide into three parts. They are LD Editor, LD Player and LD Engine. These LD software tools provide a complete learning environment for the IMS Learning Design specification (IMS-LD).

RELOAD LD Editor and Player

The Reusable eLearning Object Authoring & Delivery (RELOAD) project has produced a successful metadata and content-packaging editing tool (Leeder and Morales, 2004).

The RELOAD LD Editor was created for developing the XML binding for the learning designer, organising and designing the IMS-LD and providing the user interface and designer's view (RELOAD, 2006). RELOAD is a project funded by the Joint Information Systems Committee (JISC). It is a part of the eXchange for Learning (X4L) programme, developing tools to support learning technology interoperability specifications such as IMS and SCORM (JISC, 2008).

SLeD LD Player

The Service Based Learning Design (SLeD) Player project (SLeD, 2005) was a collaboration between the UK Open University (UKOU) and the Open University of the Netherlands (OUNL). The SLeD project (Weller *et al.,* 2006) produced a software player which is a small '.jar' file embedded in and working with the CopperCore Engine, to render the IMS-LD online courses for learners.

CopperCore LD Engine

The CopperCore LD Engine is a back-end engine for running an IMS Learning Design package. It also includes an LD Player that was developed at the OUNL. It comes with a basic web-based front-end user interface, but is designed such that people can develop their own front-end for it (CopperCore, 2007). The CopperCore LD Engine is a JISC (2008) funded project, which is called CopperCore Service Integration (CCSI). The CopperCore LD Engine is the first software to fully implement the IMS-LD specification (CopperCore, 2007).

2.4.4 *Organisations Supporting IMS-LD*

As mentioned before, the OUNL and IMS/GLC are the main organisations in the development of the IMS Learning Design specification. The OUNL created the initial IMS principles and structures in the beginning, and then the IMS/GLC have added facilities for extending and publishing the IMS-LD.

JISC

The Joint Information Systems Committee (JISC) provides specialist advice to funding bodies and educational institutions in the UK (JISC, 2008). JISC reviews its strategy periodically in consultation with the academic community to ensure that it continues to meet their needs. JISC also provides a centralised and co-ordinated direction for the development of the infrastructure and tools. JISC supported projects for developing the already described CopperCore LD Engine, SLeD LD Player, and RELOAD LD Editor and Player.

Moodle

Moodle is a Course Management System (CMS). It is a free, Open Source software package designed using pedagogical principles, to help educators create effective online learning communities (Moodle, 2008). Moodle has been disseminated widely with more than 330,000 registered users, 42,000 register websites and translations into 70 languages (Moodle, 2008). Moodle aims to provide a well-know and easy-to-learn CMS and an active community of users and researchers. Because of its Open Source and research focus it can accommodate new initiatives and experiments with modern specifications such as IMS-LD and SCORM.

SCORM

The Sharable Content Object Reference Model (SCORM) is a collection of standards and specifications adapted from multiple sources to provide a comprehensive suite of e-Learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content (ADL, 2008; Dodds, 2001). SCORM was developed by the Department of Defence (DoD) of US in 2000 (SCORM, 2007). It aims to define a standard for e-Learning content, such as content reusability, accessibility, durability and interoperability (Shoikova and Ivanova, 2006; Tattersall *et al.*, 2006).

2.4.5 *Summary of the IMS-LD Development Environment*

In summary, the IMS Learning Design specification technical supports offer a range of services. Generally, the web technologies support the elements of structure of the IMS-LD. The LD software tools are used for running the LD processes and services. The LD organisations research and develop IMS specifications and disseminate them. They support the IMS-LD to provide a stable learning process for learners. This research investigation aims to extend or adapted the IMS-LD specification to suit the learner with special needs.

2.5 Evaluation Techniques

In the following section the theory supporting evaluation design and evaluation processes are described.

2.5.1 *Evaluation Design*

According to Ardito *et al.* (2005), the evaluation of an e-Learning course needs to consider three relevant characteristics, which are its accessibility, usability and effectiveness. We describe here the criteria for evaluation of online courses based on the North American Council for Online Learning (NACOL, 2007) and Wright's recommendation (2007). The researcher should design a suitable evaluation method to measure a lesson or prototype lesson's function.

The evaluation phase should be designed to focus on the quality of materials produced (Wright, 2007). The design of evaluation includes three parts to test the characteristics of the prototypes. These are illustrated in *Figure 2-3*.

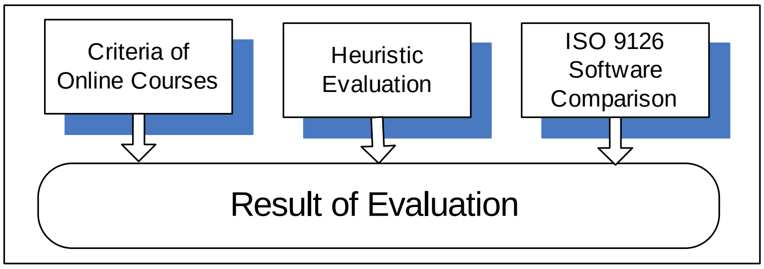

Figure 2-3: Design of Evaluation

The developer (researcher) can test the prototype lesson from a technical viewpoint and a software tools' environment viewpoint. The aim is to test for any potential risks at run-time, for example, web technologies conflict, or software accessibility.

The researcher can adopt and prepare for the heuristic evaluation technique, to evaluate the prototype lesson in use (Nielsen, 1994; Nielsen, 1993). Essentially, these usability inspection methods could help the researcher to focus on usability problems. During this stage, the researcher could prepare an evaluation session. This session could be designed to invite the expert group as inspectors, to:

- Test and trial the prototype lesson
- Complete a questionnaire and add comments.

The researcher may also do a comparison document between the IMS Learning Design specification (IMS-LD) with the SCORM standard for online learning content. This stage could focus on the effectiveness of the IMS-LD. The International Organization for Standardization 9126 (ISO 9126) quality service standard (ISO/IEC, 2008; Chua and Dyson, 2004) could support an evaluation of these two standards. The advantages and challenges of the IMS-LD could be thus documented.

2.5.2 *Heuristic Evaluation*

According to Nielsen's principles (1993), 'Heuristic evaluation is a systematic inspection of a user interface design for usability'. Its list of guidelines are summarised in *Figure 2-4*.

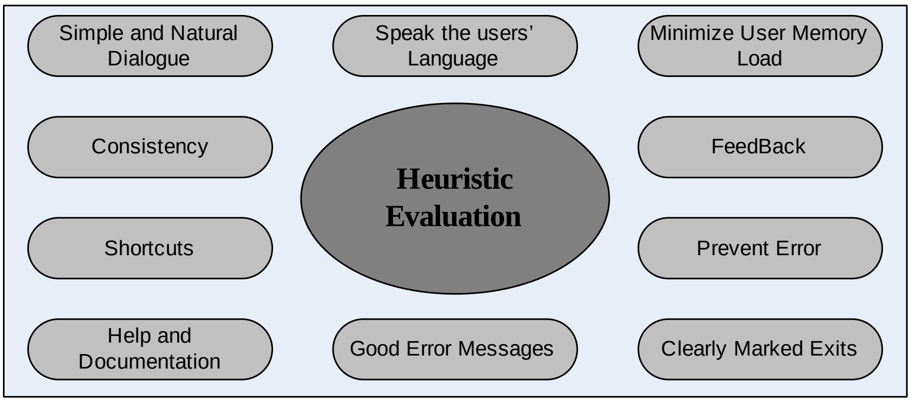

Figure 2-4: Heuristic Evaluation Usability Principles (adapted from Nielsen, 1993)

During the heuristic evaluation process, each individual evaluator inspects the interface (Nielsen, 1994). Heuristic evaluation gives guidelines so that each aspect of the interface elements is examined by each evaluator.

The evaluation processes consist of a set of steps to assess the design and implementation aspects. Inspectors (expert users) carry out the interface and system testing. According to Nielsen (1994), the inspectors test the usability of the prototype, and provide feedback to the designer or developer (researcher).

In a triangulation approach, data will be collected from (a) the researcher and developer's observation, (b) the expert users and (c) the technical comparison exercise (IMS-LD Vs SCORM). According to Stone *et al.* (2005) and Kumar (1996), there are six steps for a data evaluation process.

Step 1: Collect data form the questionnaire, e.g., inspector’s comments and researcher’s observation.

Step 2: Clean the data.

Step 3: Code the data, and devise a measurement scale.

Step 4: Put the raw data into the frame of analysis.

Step 5: Analyse the data.

Step 6: Display the analysis results in an evaluation document.

Analysis can be supported by a spreadsheet package or statistical package for this phase. These three design approaches and subsequent data analysis steps can be used to produce evaluation findings for the online learning material.

2.6 Concluding Remarks

In reviewing the literature, to consider previous articles, journals and contributions from relevant organisations, we consider that the IMS Learning Design specification (IMS-LD) has features (Koper 2005a; Koper 2005b; IMS-LD, 2003) worth exploring for special needs support. The IMS-LD based instructional product may provide essential functions to the special education tutors in the form of reusable learning scenarios.

Level A contains the core vocabulary needed to describe content and support pedagogical diversity; Level B is used to describe learning objects in more detail by linking them to specific learning activities; Level C supports multiple roles and learning activities within the networked environment.

We propose that the IMS-LD Level B could be used to support and develop learning scenarios for learners with autism, and this will be examined further in subsequent research steps. The next step therefore will be to apply the relevant elements of the IMS-LD specification to an actual online learning scenario.

3. Chapter Three: Analysis of the Research Context

3.1 Introduction

The overall steps for the analysis phase are incorporated into *Figure 3-5*. Three aspects are adopted within the research approach. They are: Research perspective, System perspective and Practical perspective.

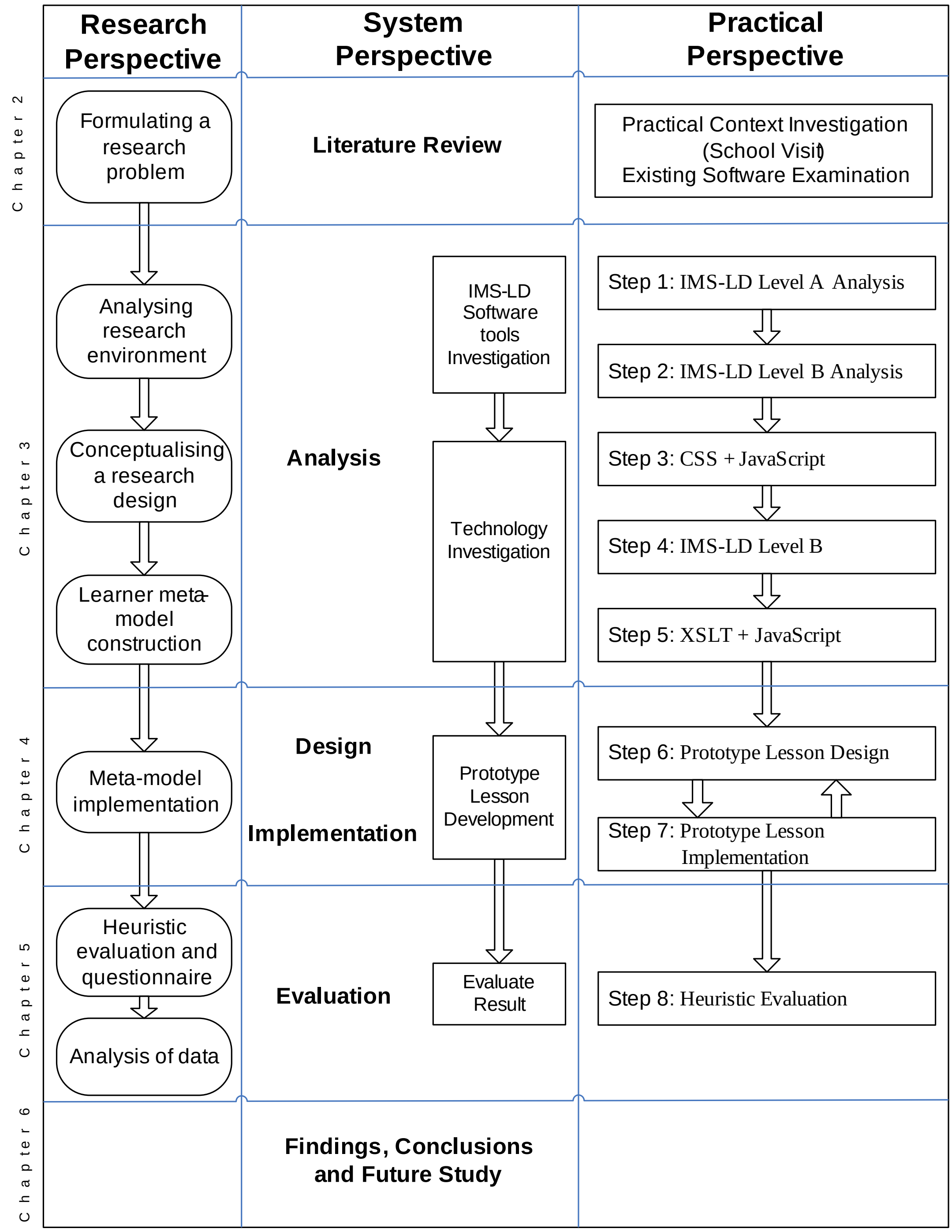

Figure 3-5: Research, Design and Implementation (adapted from Kumar, 1996)

According to Pressman (2005) and Kumar (1996), the steps shown offer a controlled and systematic framework for an investigation. The framework proposed here (*Figure 3-5*) aligns the steps that need to be undertaken in the research with the technical aspects to support these steps, and the practical implementation of a prototype lesson that leads to findings for the research.

This chapter aims to analyse the existing system environment, to ensure the IMS Learning Design specification (IMS-LD, 2003) can produce a special education online course (meta-model), in order to satisfy the learner's special needs, by applying suitable learning styles for learners with autism.

This chapter includes some ideas for planning a learning scenario and web technologies for interface design are also investigated. This chapter is divided into three sub-sections. They are:

1. A Meta-model Analysis which aims to build a model suited to the learning styles associated with autism
2. An IMS-LD Systems Analysis which aims to investigate the features of the IMS Learning Design specification to evaluate its design and capabilities
3. A Technology Analysis which aims to focus on appropriate technologies to adopt in the prototype lesson.

3.2 Meta-model Analysis

3.2.1 *Introduction*

This section focuses on the meta-model analysis, which is involved in producing a suitable model for learners with autism. This is divided into user and learner profile analysis, special learning styles analysis, meta-model process and technical support.

3.2.2 *User Profile Analysis*

User Hierarchy

The hierarchy of users in the system is illustrated in *Figure 3-6*. It shows that the user of the system can be divided into two groups of people, Administrator and Learner. The Administrator can be further divided into the LD Designer and Special Education Needs (SEN) tutor. For each group in the user hierarchy, particular actions (events) in the system run-time can be included.

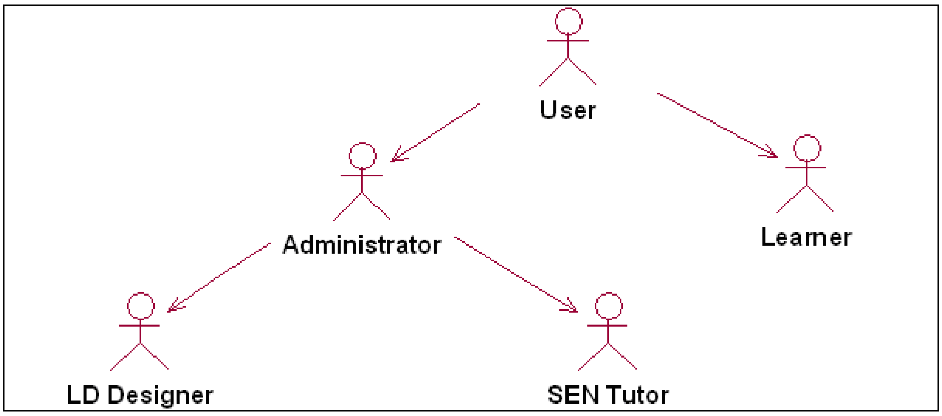

Figure 3-6: User Hierarchy in Lesson Design and Use

User Relationships

Figure 3-7 indicates the roles. A SEN tutor manages one or more learners, a LD designer produces one or more learning designs, and a learning design suits a particular learner.

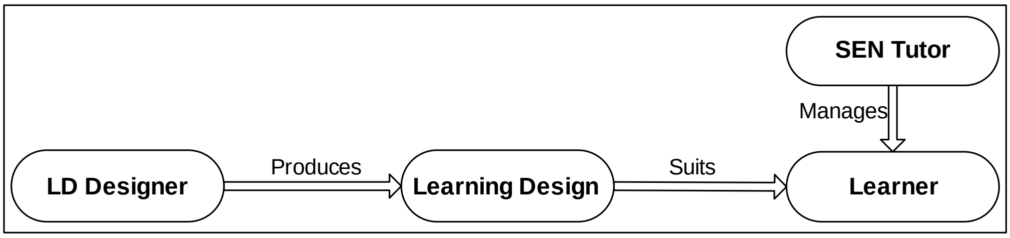

Figure 3-7: User Relationships

The researcher visited a special needs school to observe learning processes. Special needs software was also examined in order to gain insight into learner needs.

Users in the System

In the development process and the run-time environment, the different users have different actions. These actions are illustrated in *Figure 3-8*. The administrator has the responsibility of preparing and presenting the learning scenarios for learners, e.g., the SEN tutor has to document the learners' special needs, and the LD designer has to design the learning scenarios based on the learner's needs.

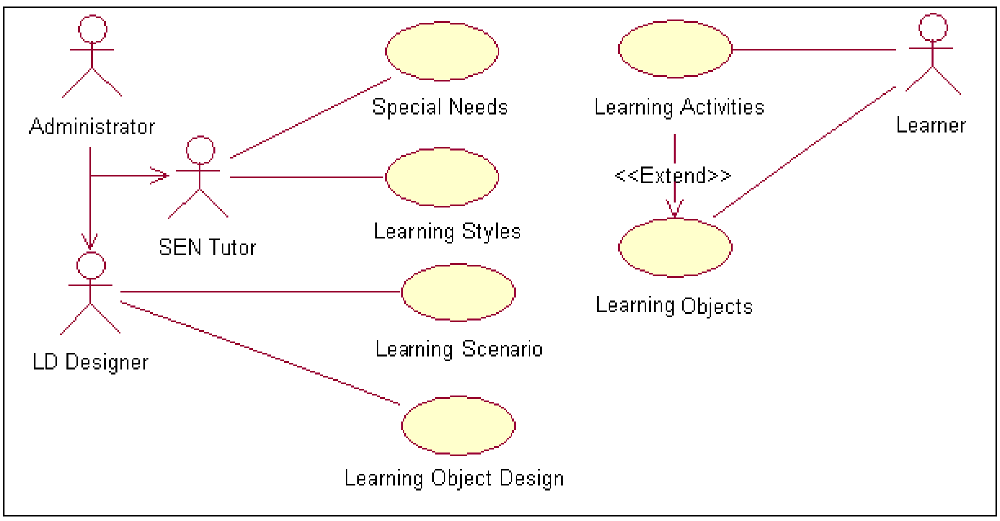

Figure 3-8: User Analysis in the Use Case Diagram

3.2.3 *Learner Profile Analysis*

Learner Description

In this research project, the learner's description has to be built. The following information describes a learner with autism, who is suitable for the research project. These characteristics are:

- Gender: Male or Female
- Age: 6 – 9 years
- Level of Autism: Mild
- Level of Computer Literacy: The learner with a mild form of Autism Spectrum Disorders (ASD), who can use a computer to achieve the learning activities. The learner also can complete a short Unit of Learning (UoL) under the tutor's instruction.

It is not within the scope of this technical investigation to evaluate the outcomes with real learners. Technical possibilities of the IMS-LD specification are examined for appropriateness for special needs education. An expert user group is used to evaluate the technical outcomes.

Learner Profile

The learner profile may focus on the learner's hobby and preferences, in order to produce the learner-based learning scenarios (Goodlin-Jones and Solomon, 2003). For example, the hobbies may include cars, animals or trains. The preferences may include shorter learning activities, certain colours, short texts, and reinforcers (for motivation) in the learning process. A reinforcer could be a small animation that is given as a reward at certain intervals in the lesson.

The profile should have two aspects to record the learner's special needs. One is a personal profile and one is an ability profile. Example content for these two aspects is described in *Table 3-1*.

Table 3-1: Individual Learner Profile

Learner Personal Profile	Learner Ability Profile
Name	Language level
Age	Memory ability
Gender	Mathematics level
Level of autism	Cognitive level
Learner education details	Object recognition ability
Learner general details	

Learner Responses

Within the learning process, there are three kinds of responses possible. One is a correct response, when the learner achieves the learning goal. Another one is an incorrect response, due to some misunderstanding. The last one is no response, which may indicate a lack of interest or understanding (Hanbury, 2005). The system must cater for all these possibilities.

3.2.4 *Learning Styles Analysis*

Children with autism have their special abilities, e.g., they may have a mechanical operational ability; they may have a strong sense for distinguishing certain objects; they may have extremely good memory; or they may have a talent in mathematics (Hanbury, 2005). The goal of the learning is not only to present learning content to learners, but also to explore their potential as much as possible (Moor, 2002).

Figure 3-9 depicts aspects of learning styles. These attributes of a learner's characteristics are listed in Chapter 2: Literature Review. The learning styles are also analysed in the following paragraphs. Some strategies to support learning are included.

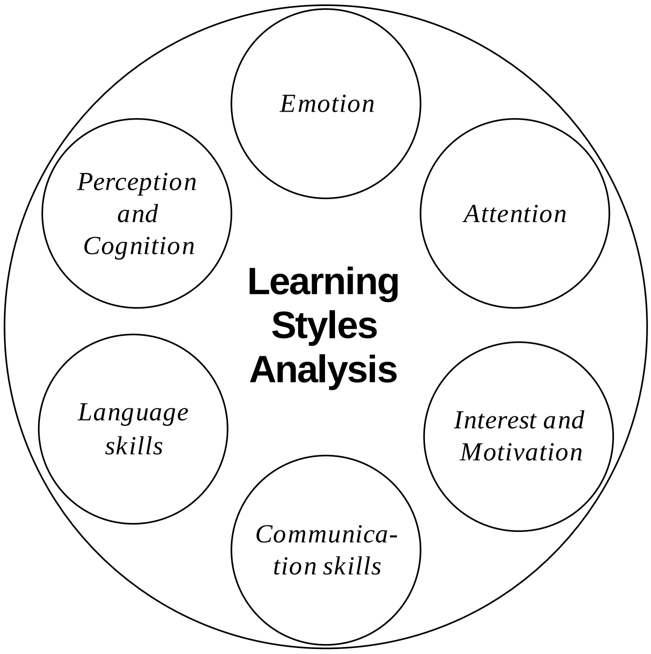

Figure 3-9: Aspects of Learning Styles

- Attention: to improve attention, we can make the learning environment more interesting for learners, e.g., we can include multimedia and animation in the learning content. However, we must avoid distraction, to ensure effective learning. Also it is necessary to give a hint or preview, e.g., to prepare the learners for the next step in the learning activity.
- Language skills: to support language skills an audio voice-over can be added.
- Perception and Cognition: animations can support the understanding of verbs and actions.

- Interest and Motivation: the course designer can offer lots of conditions for course activities, e.g., according to the users' preferences, the colour of the interface can be changed, and the background sound can be set to mute.
- Communication skills: sharing the lesson experience with the tutor or another user may support communication needs.
- Emotion: the SEN tutor can observe learners' emotions, e.g., relax them with music and help to re-focus their attention on the lesson.

3.2.5 *Meta-model Process*

In this research project, a meta-model is specified by the IMS-LD to provide for learning styles. The process of learning activities in the IMS environment is illustrated in *Figure 3-10*.

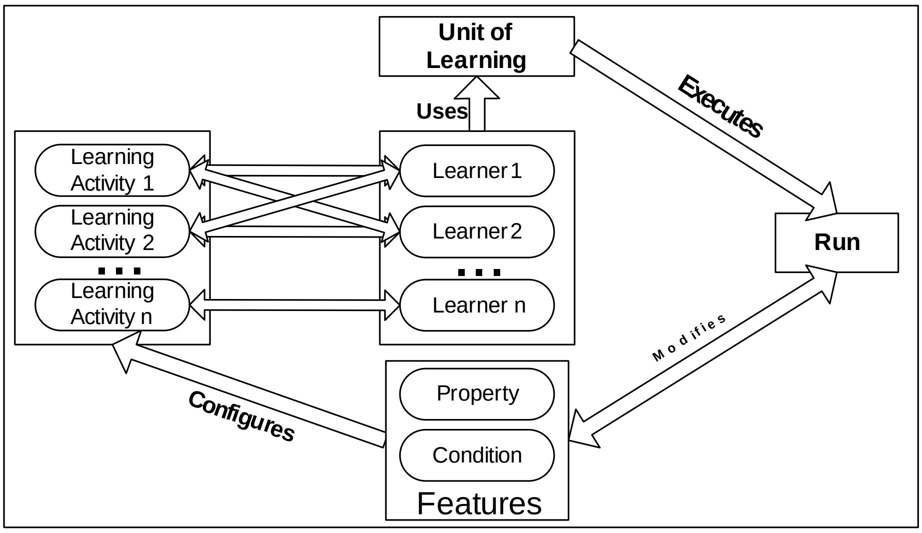

Figure 3-10: Support for Learning Activities in IMS-LD Environment

Initially, the Unit of Learning (UoL) is produced by the LD designer. Then, the learner uses the UoL. The IMS-LD Level B features (Property and Condition) are dynamically modified during lesson execution time, and provide the particular learning activity for the particular learner. The learner could take one or any number of learning activities during the learning session. The Run is a logical process (lesson execution) which is described in section 3.3.7: IMS-LD Level B Features.

3.2.6 *Meta-model with Web Technologies*

To support the meta-model, certain technologies are used to implement the UoL (prototype lesson) in the IMS environment. As documented in Chapter 2: Literature Review, a number of technologies could be integrated into the meta-model implementation framework as illustrated in *Figure 3-11*.

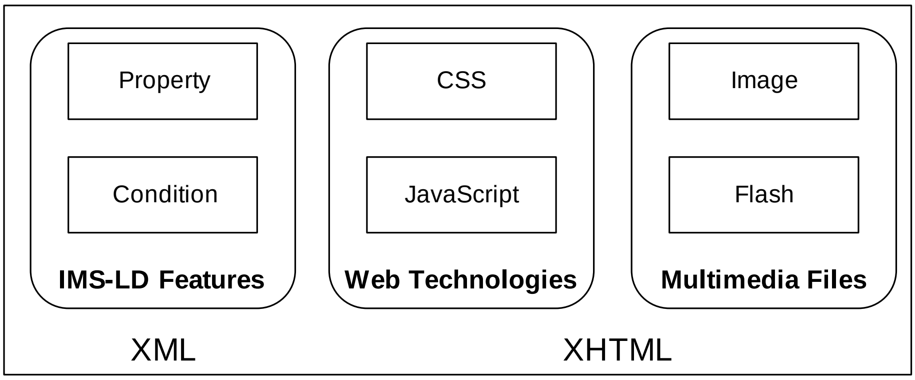

Figure 3-11: Integration of IMS Meta-model with Web Technologies

The IMS Manifest (XML) file contains the IMS-LD features (Property and Condition), which are indicators for presenting learning content files by XHTML technology. The learning content is presented via web technologies and multimedia files. The web technologies (CSS and JavaScript) provide a suitable learning style for the individual learner. The multimedia files (Image and Flash) enhance learner interest, attraction and attention.

3.3 IMS-LD System Analysis

3.3.1 *Introduction*

This IMS-LD system aims to satisfy learners' special needs, to integrate with computer technology and to provide learning materials online. In the following section, we use the Unified Modelling Language (UML) to describe how the IMS-LD may suit the development of online special needs educational courses.

According to Dennis *et al.* (2004) 'a methodology is a formalised approach to implementing the system development life cycle.' There are different systems development methodologies, each one used to support a different development phase in software development. The researcher has adopted the prototyping-based methodology (*Figure 3-12*) to structure the system in the present research investigation.

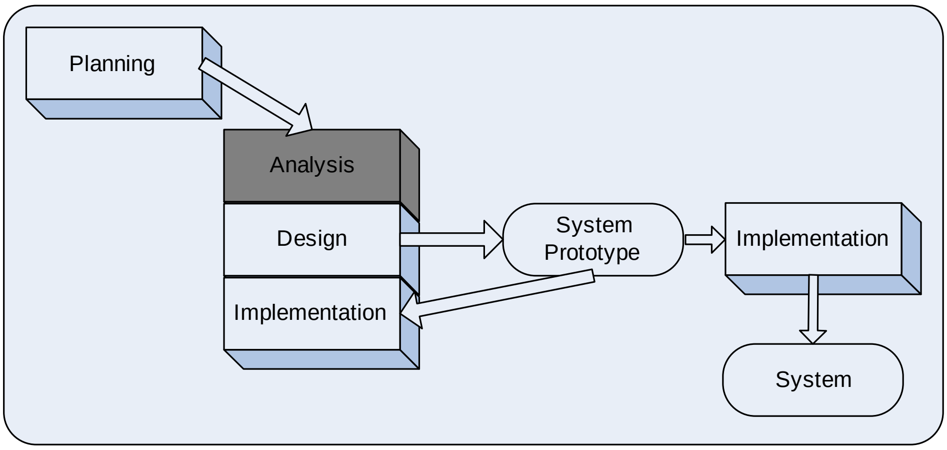

Figure 3-12: Analysis in Lesson Development (redrawn from Dennis *et al.*, 2004)

3.3.2 *Analysis of IMS-LD Levels*

IMS-LD Level A

IMS Learning Design specification (IMS-LD) Level A can develop and deliver the basic learning activity and learning scenarios (IMS-LD, 2003). Therefore, a lesson has to provide the option to suit learners' cognitive styles, e.g., temporarily exiting the course, providing short breaks, and providing motivation and encouragement.

Depending on a learner's special needs, this may include a learning file with sound (if needed), with animation (if needed), and with a particular colour, font and background. These are then incorporated into a user profile available for the course, the activities, and the practice exercises.

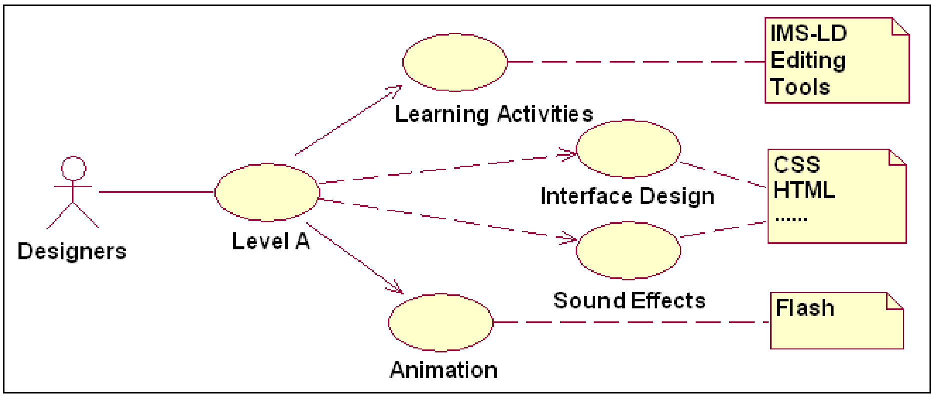

Figure 3-13: Level A Requirements and Processes for Learner Support

The design may require multimedia and web technologies for the course development, e.g., Flash and CSS may be embedded into web-based learning pages. The basic components of the user profile and these supporting technologies are illustrated in the use-case diagram in *Figure 3-13*.

IMS-LD Level B

The IMS-LD Level B can provide Properties and Conditions features (IMS-LD, 2003). The features of Level B are better used for managing learners' Properties in dossier files, controlling and monitoring the learning flow, and also providing more Conditions for learning activities in the learning scenario.

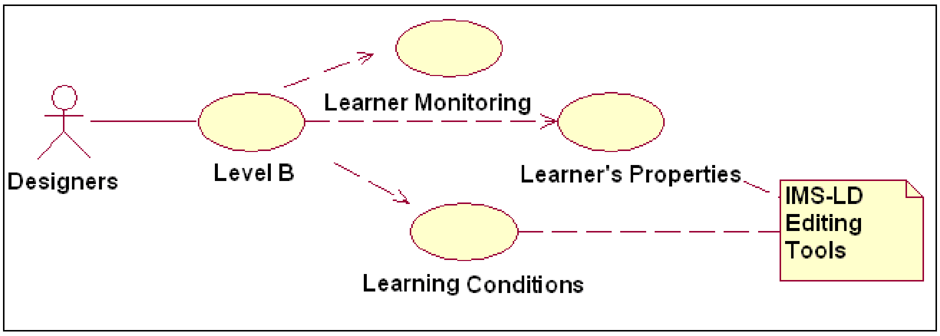

Figure 3-14: Level B Requirements and Processes for Learner Support

These features require the designer to prepare learning materials, and incorporate the features of Level B using the IMS-LD Editing Tools. The details are shown in *Figure 3-14*.

Comparison of IMS-LD Level A and Level B

While the designer is working on the lesson design, there is an interchange between Level A and Level B features, depending on the learner's needs. Whatever features are adopted from these two levels, the features can be recorded in the IMS Manifest file. Then the system can display the features in the learning interface. Finally, the learner can take the appropriate lesson or course. The UML sequence diagram illustrates this approach in *Figure 3-15*.

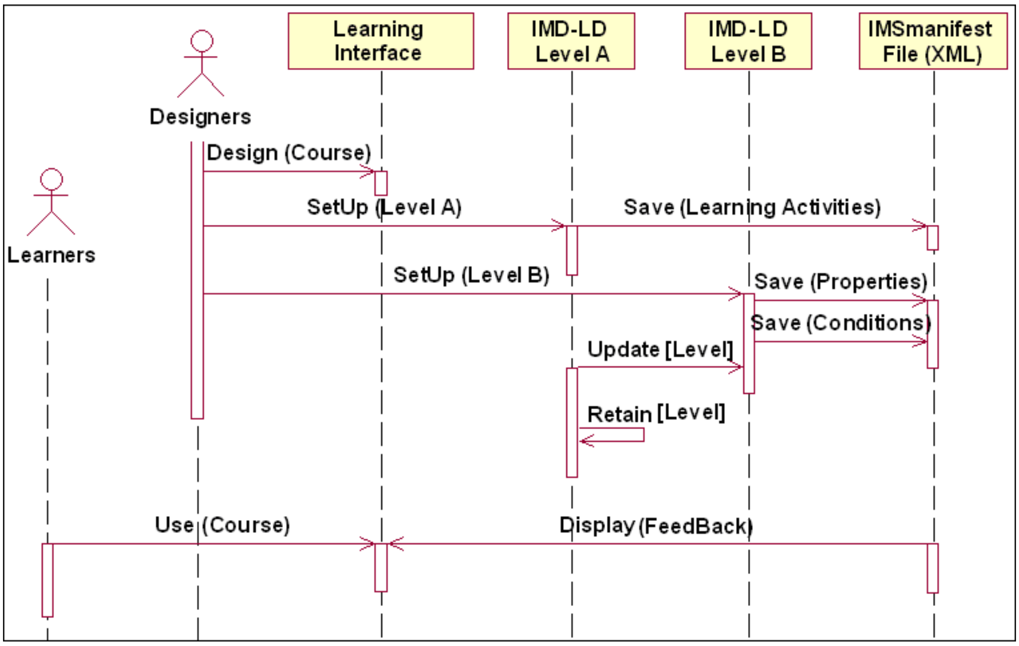

Figure 3-15: IMS-LD Level A and B Store the Learners' Features

Therefore Level A supports the basic content and Level B supports personalisation.

3.3.3 *IMS-LD Processes and Roles in System*

In this IMS-LD system, the Roles are divided into three parts. One is Special Education Needs (SEN) tutors, who analyse the learners' special needs, and then pass the information to the learning designers. LD designers (Second Role) design the Unit of Learning (UoL), make the decisions about using IMS-LD Level A or B, and then develop the IMS Learning Package. The final Role is that of the learners, who use the courses.

The SEN tutors may get feedback and change the learner's requirements, or just examine the result when the course is finished. The processes are illustrated in the *Figure 3-16* activity diagram.

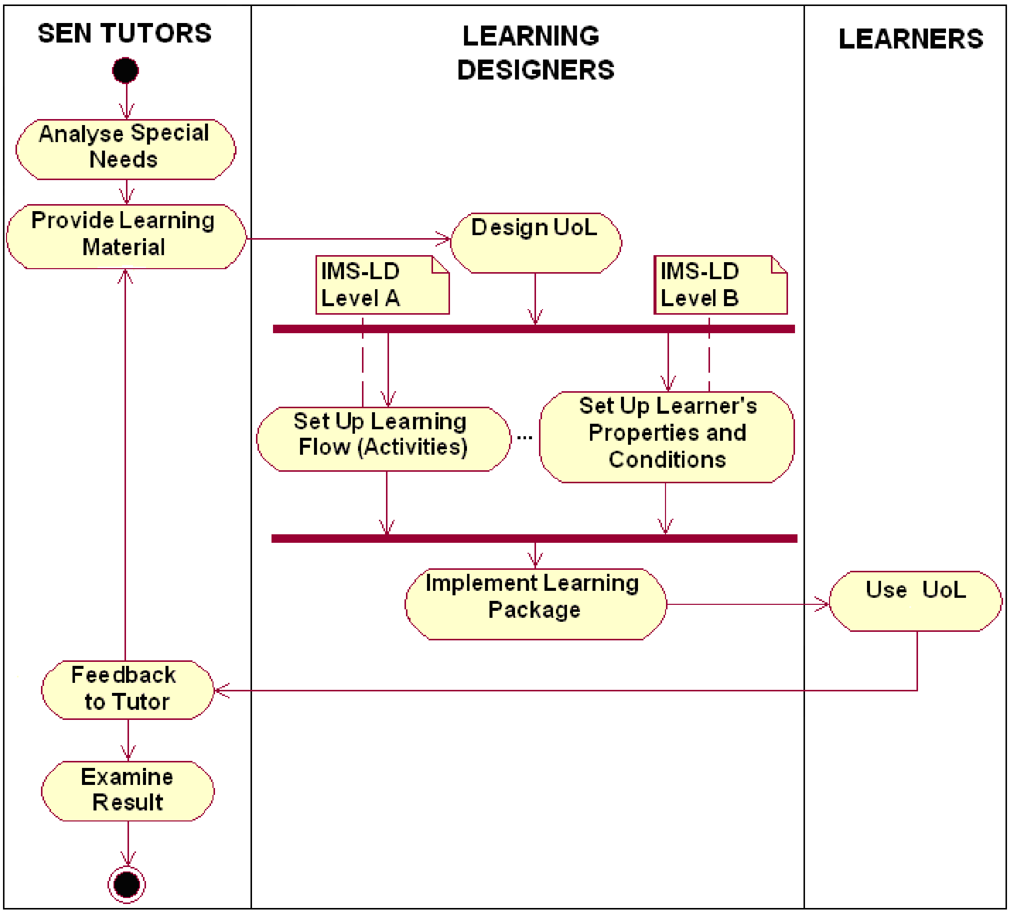

Figure 3-16: Processes in the IMS-LD to Support Learning

The IMS-LD Level B supports group learning in a single learning scenario. It means that the designer can allow different learners who have the same learning level to join into one particular group. It is a strategy that is used for organizing and managing learners, but it may only suit certain types of learners at certain stages in their learning.

The IMS-LD Level B also provides for multiple interactive Roles in the learning scenario, e.g., a learner Role or a staff Role. The different types of Roles can be incorporated simultaneously in one UoL. It means that after the learner Role has completed the learning test, then another Role can return a comment on the test. It offers the possibility of effective interaction, such as receiving feedback on the learner's progress.

3.3.4 *System Data Analysis*

The user's profile can be presented as part of the IMS-LD system data. Each learner's learning styles can be established by the SEN tutor. The learner's profile includes the favourite colour, sound, background, level of learning, and other information. The learner's information includes learner name, ID, gender, and age.

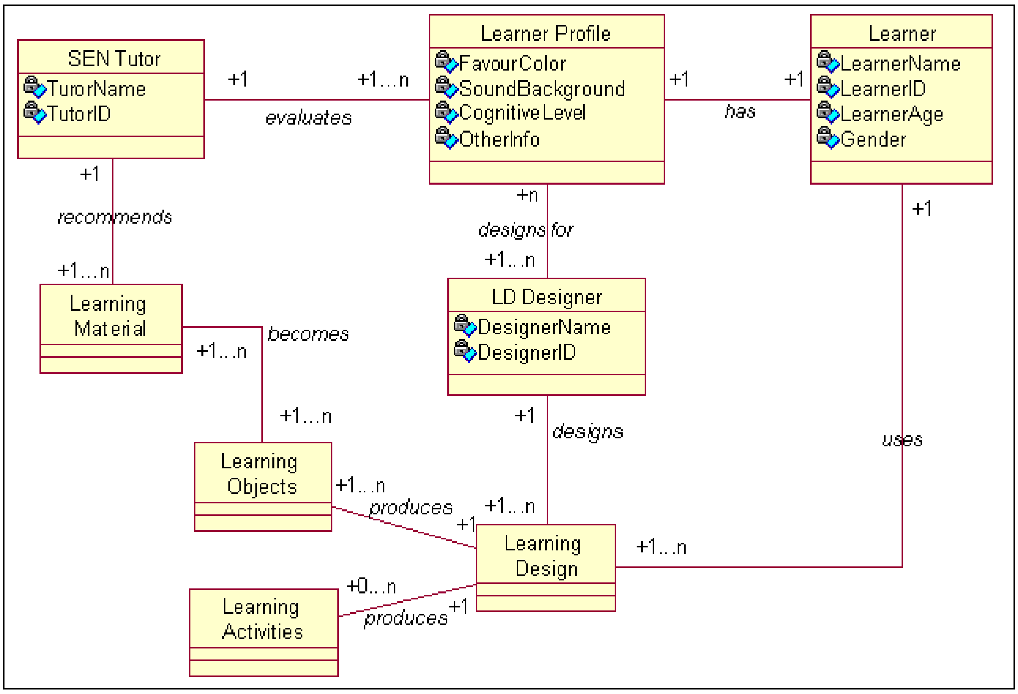

Figure 3-17: Data Flow Analysis for the Learning System

The details of the data flow are illustrated in *Figure 3-17*. The SEN tutor and LD designer also have a name and ID stored. The LD designer produces the Learning Design from the SEN tutor's observations of the learner. This researcher has gained insight into the learner characteristics by:

- Visiting a class-room for special needs learners
- Assessing specialised software for learners with autism
- Learning from the experts during the literature review phase.

3.3.5 *IMS-LD Processes and Roles*

As described in Chapter 2: Literature Review, the IMS-LD processes have been divided into two aspects, which are Methods and Components. *Figure 3-18* analyses each process of the IMS-LD.

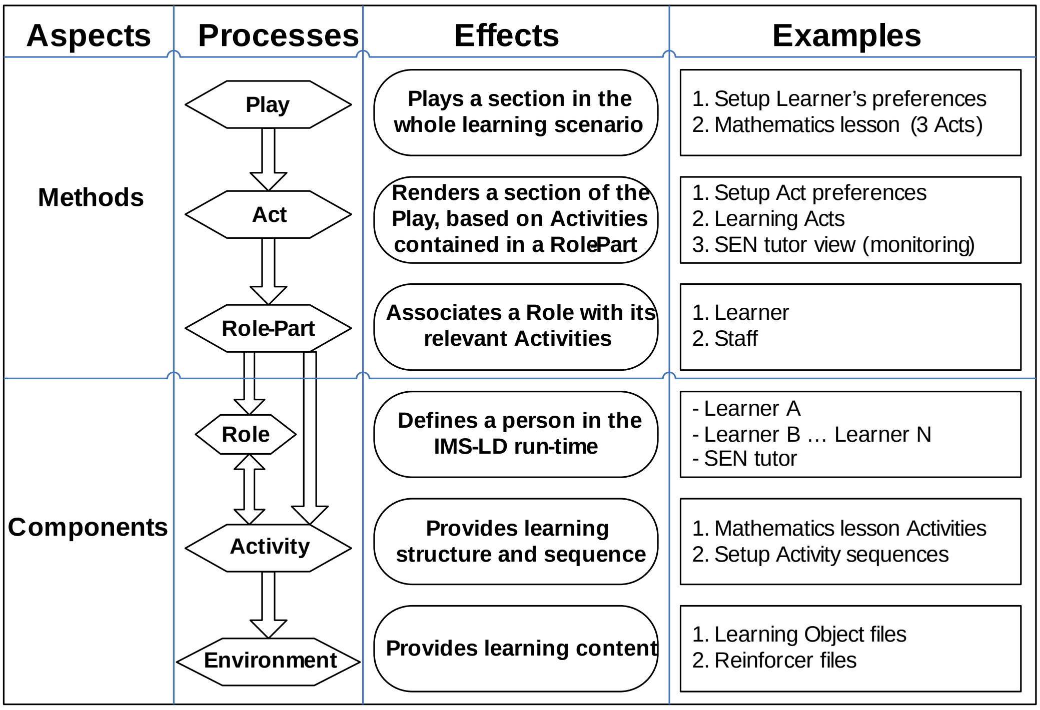

Figure 3-18: Components in Personalised Learning Configuration

The following effects are provided by processes in the IMS-LD. A Play could render a section in the learning scenario, and it consists of an Act or Acts. An Act includes Role-parts, which associate Roles with their relevant Activities. A Role defines a person in the IMS-LD run-time. An Activity provides a learning structure and sequence, and assigns an Environment to provide learning content.

3.3.6 *Unit of Learning (UoL)*

As defined by Olivier and Tattersall (2005), the Unit of Learning (UoL) is a complete learning scenario or lesson, developed according to the IMS Learning Design specification. It is the smallest learning activity that can be used to deliver the learning objectives to learners.

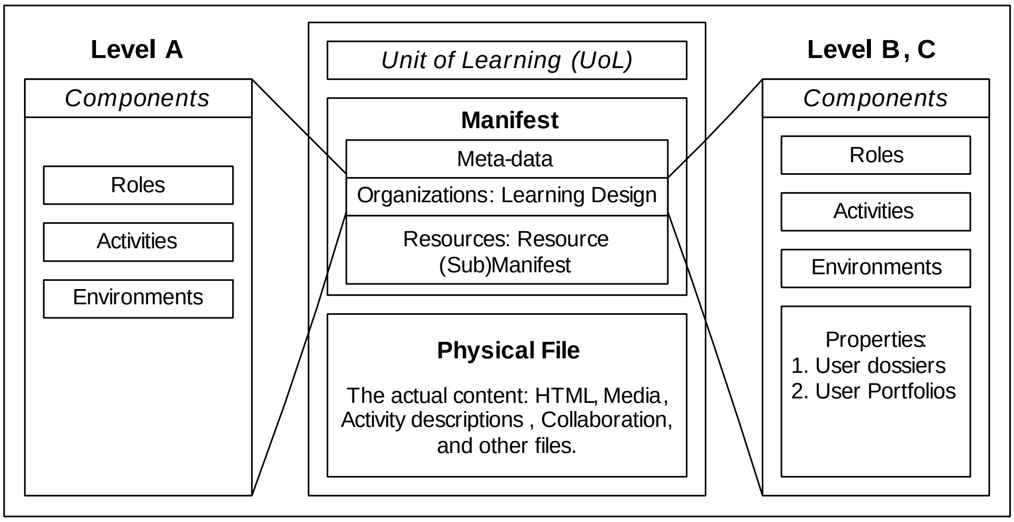

Figure 3-19: Components in the UoL Package (adapted from IMS-LD, 2003)

As illustrated in *Figure 3-19*, two main types of files are included in a UoL. They are the learning material files (physical files) and the manifest file (XML-based file). The Learning Design has some different components between Level A and B. There are Roles, Activities and Environment components in Level A. There are Property components in Level B and C, and also original components from Level A. The Properties are used for recording and storing users' and learners' information into dossiers (profile) and portfolios (work achieved).

3.3.7 *IMS-LD Level B Features*

As noted in Chapter 2: Literature Review, the IMS-LD Level B has two main features (Property and Condition). In the following section, these two features are analysed from the point of view of the IMS-LD (2003) specification, as detailed in its standard documentation.

Global Property and Local Property Scope

A Global Property can display and deliver its value across the IMS Unit of Learning (UoL). It can describe Roles in the system. However the Global Personal Property only delivers values for a particular person (e.g. individual learner). The Global Property and Global Personal Property have to be defined only once for all UoLs.

A Local Property can provide values within a Run (execution) of one UoL. In a different Run, it may have a different value. Local Personal Properties and Local Role Properties are associated with the particular person and his or her Role. The options of the Properties' authority (permissions) are illustrated in *Figure 3-20*.

Types of Properties	Property Scope Detail	Example
Global Property	**Can be viewed in all UoLs by all persons**	General learning information
Global Personal Property	**Can be viewed in all UoLs by a particular person**	Learner's name
Local Property	**Can be viewed within a UoL in a Run by all persons**	Math lesson 1
Local Role Property	**Can be viewed within a UoL in a Run by the same Role**	Learner at Beginning Level
Local Personal Property	**Can be viewed within a UoL in a Run by a particular person**	Learning activity completed (status)

Figure 3-20: The Options of the Properties' Authority

The Global Properties can work across all the UoLs in the LD environment; the Local Properties can only retain their values within the Run. The Run is a logical process. It assigns the users to the teaching-learning activities (scenarios). It is defined by the IMS-LD (2003) as follows, 'a Run is an abstraction that combines a particular learning design with a community of users assigned to that learning design.'

An LD environment may have one or more UoLs. One UoL may accommodate one or more Runs. The scope and comparison between Global Properties and Local Properties is shown in *Figure 3-21*.

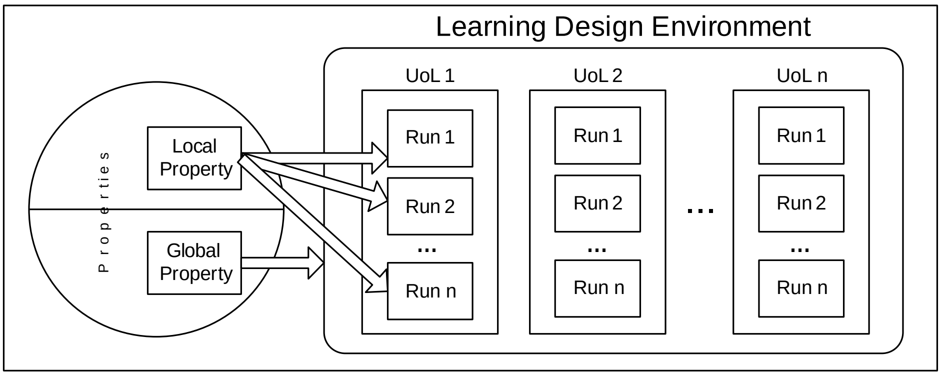

Figure 3-21: Scope of Local Properties and Global Properties in LD Environment

Considerable experimentation is needed at this stage to fully understand and apply the IMS-LD Properties.

The Flexibility of the Condition Feature

The Condition feature is used to tailor the learning content, to ensure the accessibility of an activity, and to conditionally change the value of Properties (Koper and Miao, 2007). The list of items involved in the programming of the Condition feature is illustrated in *Figure 3-22*. This research has experimented with 'showing and hiding' different activities to achieve and to support an adaptable interface and a variety of learning activities.

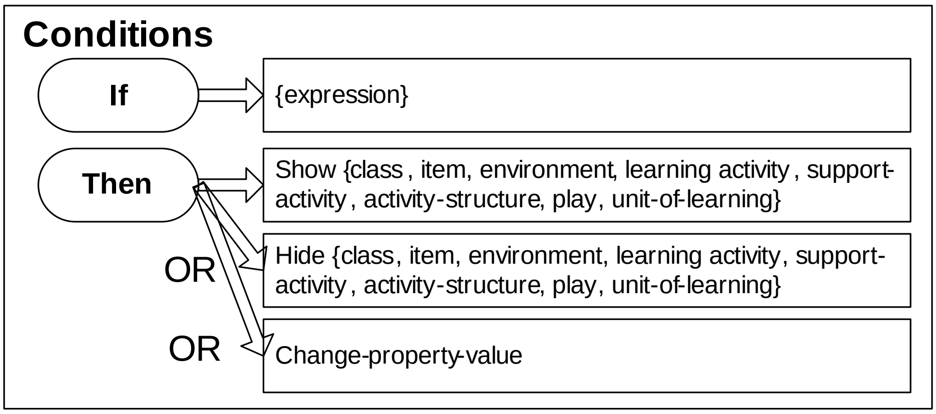

Figure 3-22: Condition Controls Learning Activities (redrawn from Koper, 2005b)

The Condition feature of the IMS-LD Level B uses the 'if-then-else' rule to provide dynamic learning activities in learning scenarios. Furthermore, the learning activity can be adaptively and repeatedly used for an individual learner, to suit his or her learning styles. So, the Condition feature could help the learner to learn, by using special learning scenarios.

To summarise this analysis section, it outlines the role of the IMS-LD in a framework for an e-Learning environment and applications which integrate new methods and services for active and adaptive e-Learning. In particular, Level B may have the advantage of dynamically configuring its features to provide appropriate activities.

Therefore the framework is worth exploring further in relation to software development for special needs education. A standards-based framework applied to special education software design, could contribute to the overall design process, for configurable online learning scenarios.

3.4 Technology Analysis

3.4.1 *Introduction*

This section focuses on the IMS Learning Design specification (IMS-LD) and the appropriate technical environment investigated in the technology analysis and the initial prototype design. We record the practical steps undertaken in the research project, in order to investigate the technology, tools, and techniques needed.

The outcome of this technology analysis is a series of prototypes in preparation for the design phase of the research project. This practical study is divided into two parts, system testing and prototype planning. We now describe and illustrate these two parts.

3.4.2 *Software Tools Analysis*

The relevant software tools which support the IMS Learning Design specification (IMS-LD, 2003) include the LD Editor, LD Engine and LD Player, as outlined in Chapter 2: Literature Review. The IMS-LD software tools aim to support the whole system, from editing learning packages to setting up a Virtual Learning Environment (VLE) for use by the end-user or learner. Within the learning package, the lessons, also called Units of Learning (UoLs), can be used frequently and remain accessible online (Koper, 2005a).

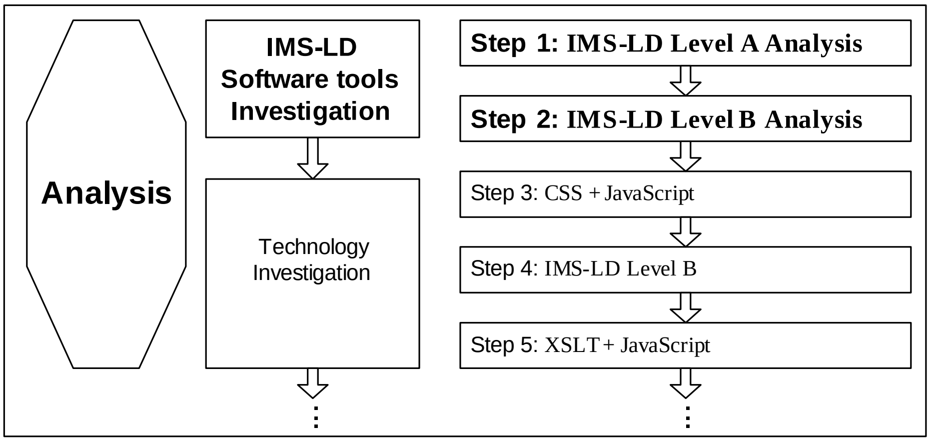

Figure 3-23: Steps 1 and 2, IMS-LD Level A and B Testing in the Project Process

Step 1 and Step 2 are described in the next section and they are illustrated in *Figure 3-23*. The IMS-LD Editor can produce the Content Package (IMS-CP, 2005), which includes the learning materials and learning activities, and other services, for example, the monitoring and control of the learning process (IMS/GLC, 2008). The system testing, in this early investigative phase, is focused on the software tools analysis and IMS-LD Level A and B features analysis.

Step 1 IMS-LD Level A

IMS Learning Design Level A analysis is an initial system analysis activity in this project. It aims to investigate and test the LD software tools and how they work together, to provide a simple learning activity.

At the testing stage, the researcher has chosen the RELOAD LD Editor (RELOAD, 2006) to produce the IMS-LD Level A Units of Learning (UoLs). Then the CopperCore LD Engine (CopperCore, 2007) has been used to validate the UoL. The SLeD LD Player (SLeD, 2005) was used to run the UoL, and finally the Course Management

System, Moodle (2007) was used to host and run the UoL. The illustration of the IMS-LD tools and process steps is shown in *Figure 3-24*.

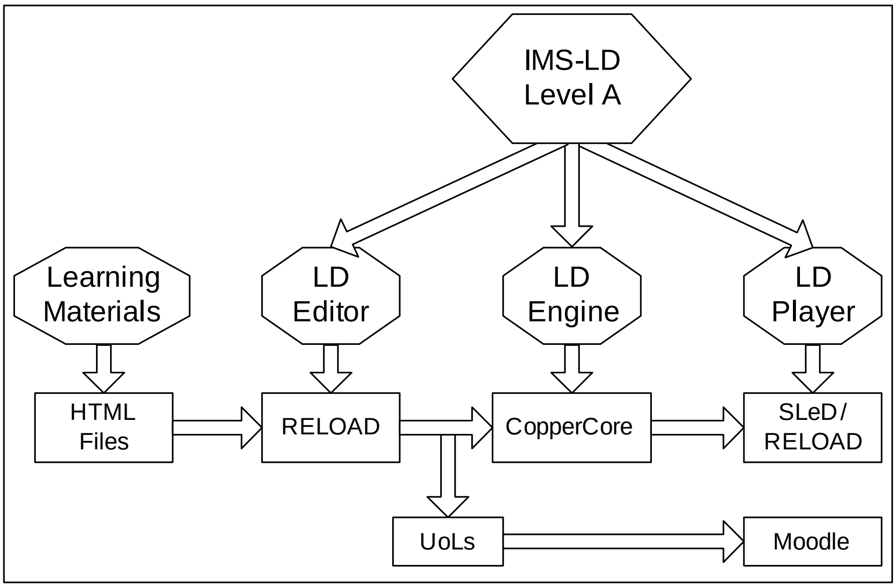

Figure 3-24: Step 1, IMS-LD Level A Software Analysis

The key aspect of this testing step was to configure the tool set and investigate:

- A simple learning activity
- A reusable UoL
- Online accessibility
- Software (version) conflict
- How the system can deliver the learner's UoL.

The result of the IMS-LD Level A analysis was that these tools can produce and run a valid UoL as an IMS content package. The basic IMS learning environment has been set up successfully, and the UoL can run in it. An extra experiment at Level A was to test the UoL in the Moodle (2007) version 1.8 VLE and this was only partly successful due to system incompatibilities. The next step is to analyse the IMS-LD Level B features relevant to this project.

Step 2 IMS-LD Level B

This step of the IMS-LD software tools analysis focuses on the features (Properties and Conditions) which the IMS-LD Level B can provide (IMS-LD, 2003). These two features may be suitable for an educational strategy which can support learners to learn. The software tools are the same as in the last step, but with a focus on the LD Editor (RELOAD LD Editor), as it can provide and edit the features of LD Level B. The features and services are outlined in *Figure 3-25*.

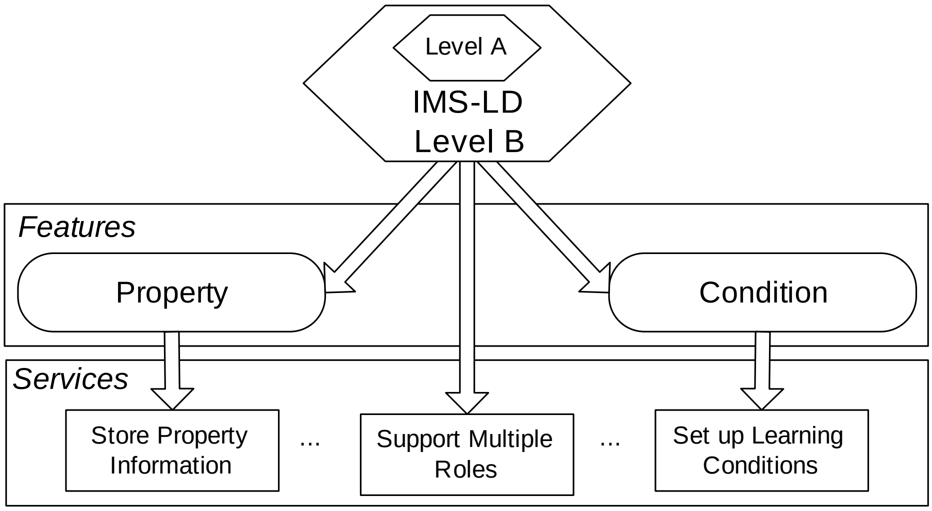

Figure 3-25: Step 2, IMS-LD Level B Features and Services

As detailed in Chapter 2: Literature Review, the IMS-LD Level B has more services than Level A, e.g., it supports multiple Roles (IMS-LD, 2003). Usually these features and services work together to provide a more effective learning experience for the learners. The Property can hold information relevant to the Roles and objectives of the course. The Condition can control and trigger the learning activities.

The special feature of Roles in the IMS-LD Level B has been analysed as IMS-LD multiple Roles services in *Figure 3-26*. The screen shot illustrates an example of multiple Roles support, where Roles are allocated. The Role may be the individual learner, or the tutor who is involved in the learning process.

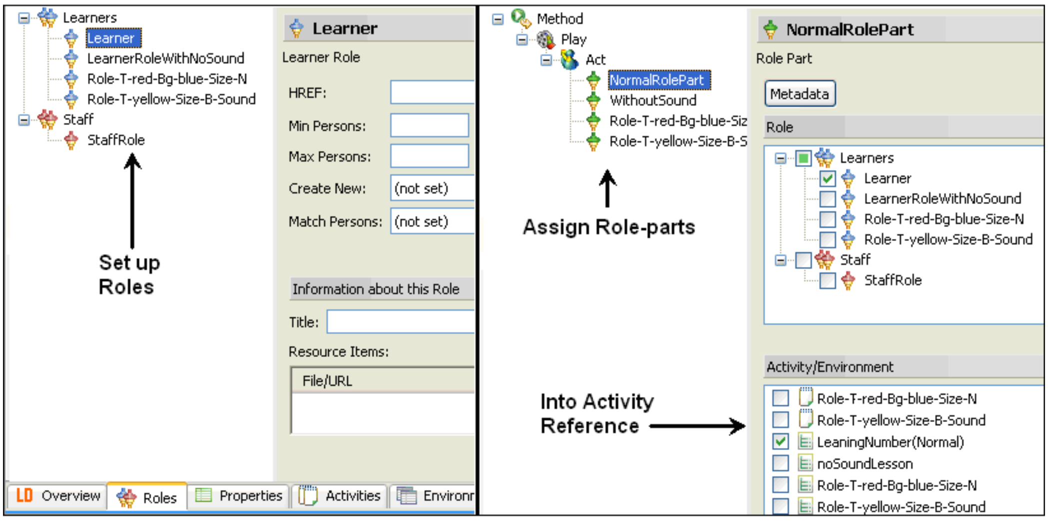

Figure 3-26: Multiple Roles and Role-parts are assigned in Activity References

Figure 3-26 also illustrates how to set up Roles and set up the Role-part in the RELOAD Editor. One Role may have one or more Role-Parts. It allows for personalisation, e.g., one learner may need the Role ‘Learner-with-sound’ while another learner may need the Role ‘Learner-with-red-and-blue-interface’. The designer could work closely with the tutor to define these individual learning needs.

The features of the IMS-LD Level B can give the course designer more options for developing the IMS-based learning package. *Figure 3-27* describes the IMS-LD Level B services and examples. These services store the learner’s profile, monitor the learner, and trigger learning activities.

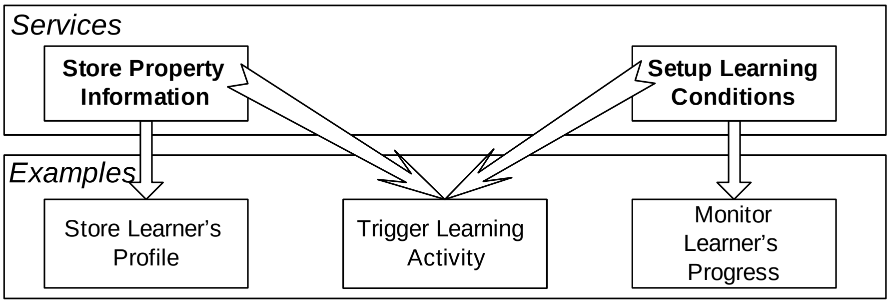

Figure 3-27: IMS-LD Level B Services and Examples

Figure 3-28 is a screen shot of the Property feature in the RELOAD LD Editor, with its XML code. The designer designs the Properties in the LD Editor, and the XML code can be build automatically.

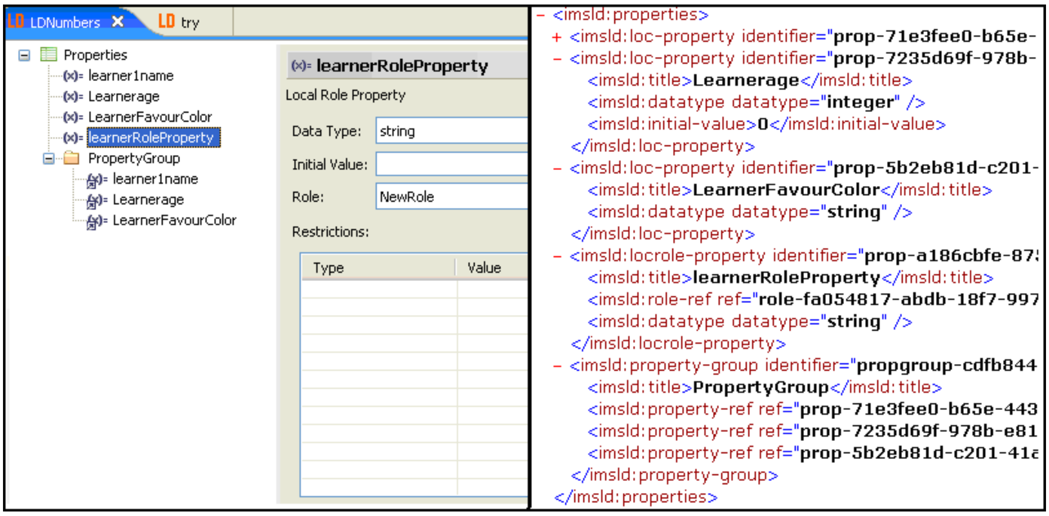

Figure 3-28: Property Feature in Designer View and Relevant XML Code

Figure 3-29 shows a screen shot for an IMS-LD Condition feature in the RELOAD LD Editor with its XML code. An If-Then-Else sentence has been provided to set up a Condition, and this also generates the relevant XML code.

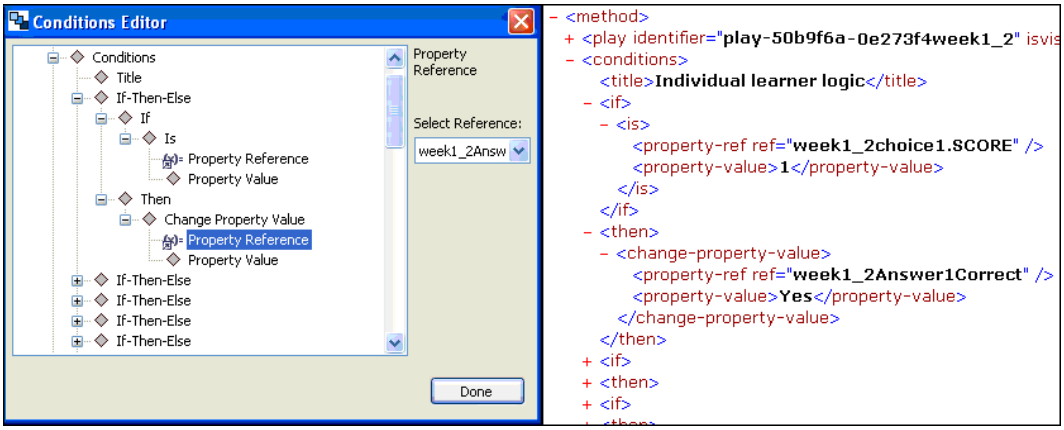

Figure 3-29: Condition Feature in Designer View and Relevant XML Code

The key aspect of this analysis step is to investigate features such as:

- Multiple Role support
- Multiple runs for learning activities
- Learner activities to be selected
- Simple assessment in the lesson
- Other relevant features (monitoring).

In summary, the IMS Learning Design Level B features have been investigated, and tested in the run-time environment in the system. For the next step, the initial prototype can be developed in order to experiment with the IMS-LD approach, in producing a lesson to use for learners with autism.

3.4.3 *Prototype Analysis*

The next three steps focus on the prototype analysis. In *Figure 3-30*, Step 3 ‘CSS + JavaScript’ and Step 4 ‘IMS-LD Level B’ are developed by adopting the IMS Learning Design specification (IMS-LD, 2003) to produce a web-based lesson.

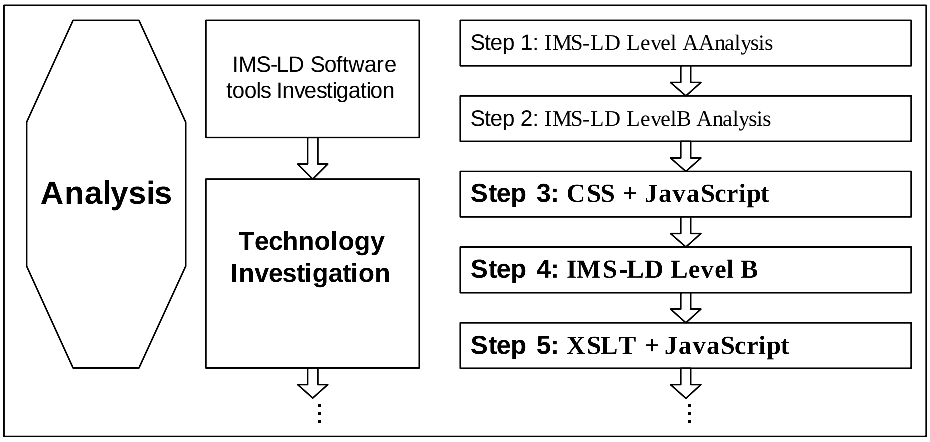

Figure 3-30: Steps 3, 4, and 5, Practical Experiments in the Project Process

Learners may require specific support during the lesson, e.g., special learning activities, an appropriate simple interface, and perhaps audio support. These special features may be suited to the learner's needs. Step 5 'XSLT + JavaScript' is used for an IMS-LD code experiment, which allows the designer to view the IMS Manifest file embedded in the UoL.

Step 3 Practical Experiment 1 (CSS + JavaScript)

This practical experiment (*Figure 3-30*) involved the use of the web technologies Cascading Style Sheets (CSS) and JavaScript (W3C, 2008). The approach was to use JavaScript technology to set up the learner's profile in a HyperText Mark-up Language (HTML) interface, and then to save the learner's profile into the newly developed CSS file. In this experiment, the designer had to set up the path for locating the CSS file, to make it ready for invoking later. Lastly, the learner would type in his name, and JavaScript invoked the pre-existing CSS file to describe the main lesson.

The IMS-LD Editor can compress these files, which included HTML, CSS and JavaScript files, into a learning content package (.zip) file. Each time the lesson was used the learner needed to type in his or her name to invoke a personal interface. This practical experiment is illustrated in *Figure 3-31*.

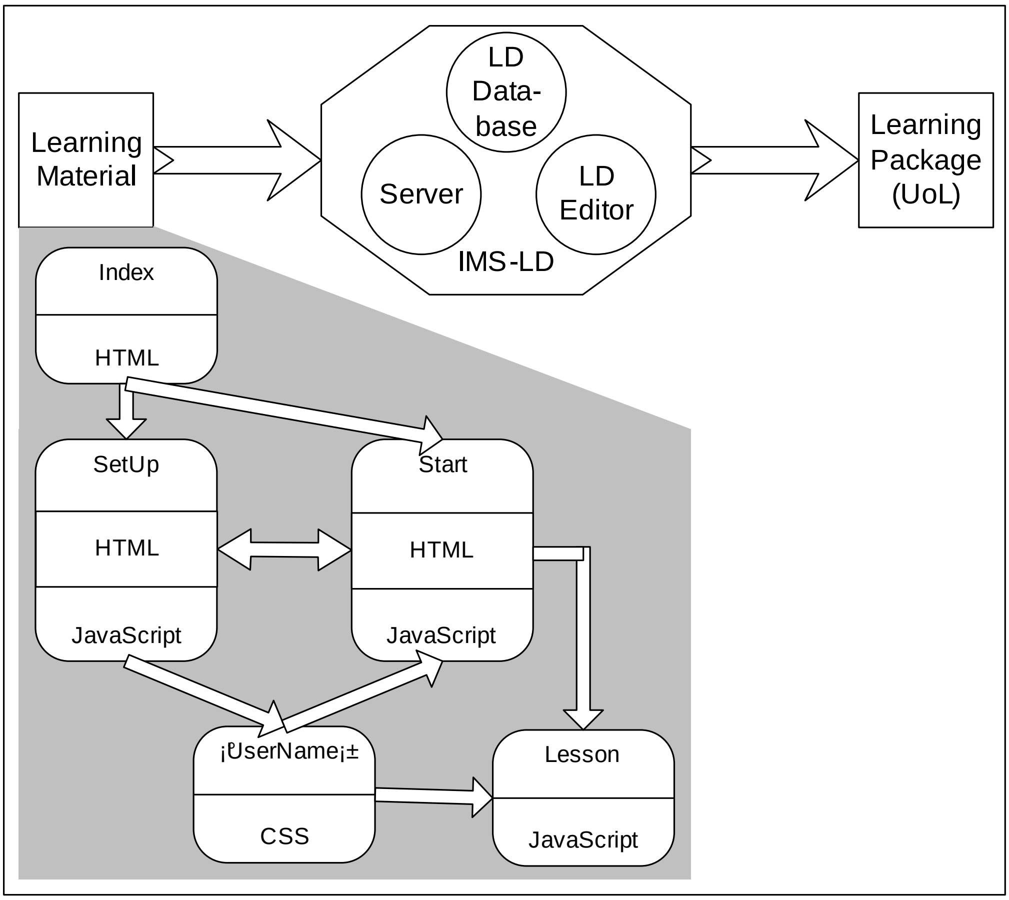

Figure 3-31: Step 3, A Practical Experiment with CSS and JavaScript Technologies

We now assess the advantages and disadvantages of this technical experiment.

Advantages

- The learner's special needs can be supported automatically. Also the lesson can associate the learner and relevant features, automatically.
- The interface is included for setting up the learner's special interface requirement. The designer can easily operate this configuration.
- It is purely a web technologies investigation at this stage, without using the IMS-LD Level B, i.e., an experiment in the convergence of technologies to support the user.

Disadvantages

- Each time, it is necessary to set up the learner's profile, and re-export the Learning Content Package.
- This practice did not use the IMS-LD Level B features. For example, it did not store the learner's profile in the database of the LD Engine.

The above step, with its advantages and disadvantages, proved to be a valuable experiment and it enriched the researcher's understanding of the technologies under investigation.

Step 4 Practical Experiment 2 (IMS-LD Level B)

The next practical step (*Figure 3-30*) uses the IMS-LD Level B features relevant to the IMS Learner Information Package (IMS-LIP, 2005). It aims to produce a lesson configured to each learner, to support his or her own special needs.

The main idea is based on using the IMS-LD Level B, which can provide for the different Roles required by a learner. A learner's requirements and relevant configuration details are then exported in one learning content package. The CSS files also can be prepared for each learner, and his or her special needs can be recorded in it. The CSS files describe the learning material files used at run-time.

Within the LD Editor, it was necessary to add all the learning materials into the UoL, setting up the different 'Role-parts' with different features for lesson web pages or learning activities.

Within the LD Player, the IMS has a feature to create a new learner, and then, to create a different Run, with appropriate Roles and Role-parts. During the learning process, the learner can choose his or her own lesson. This experiment is illustrated in *Figure 3-32*.

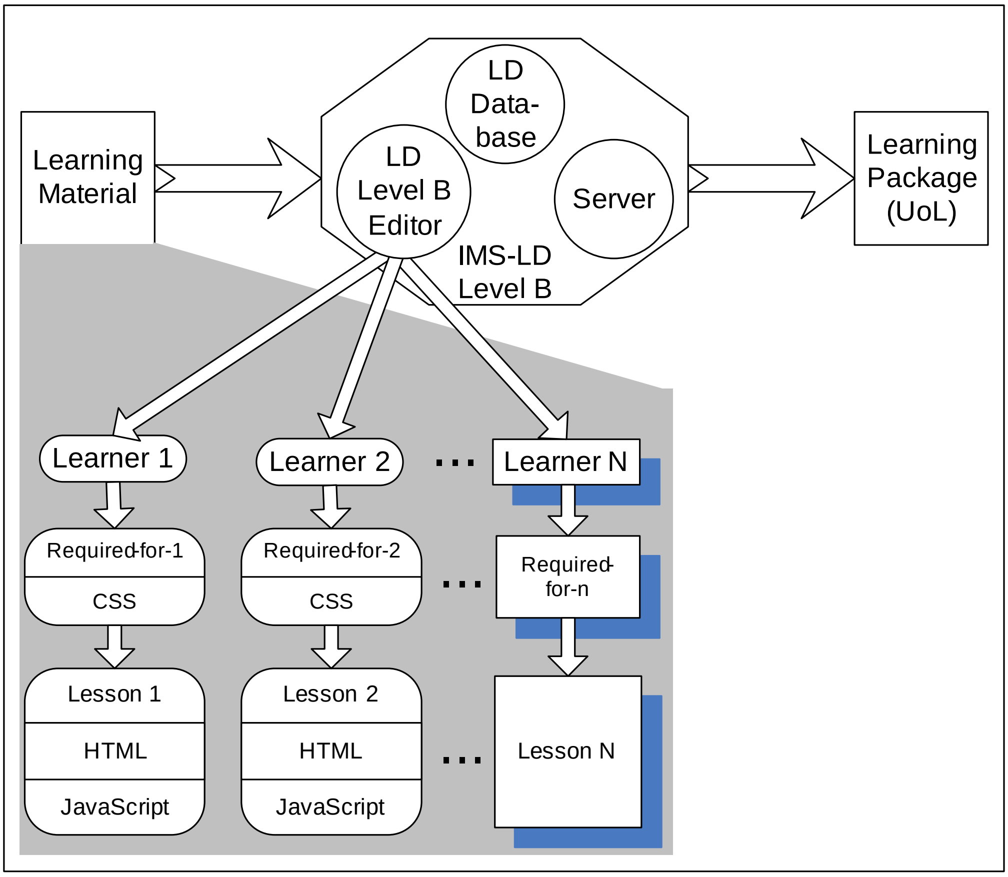

Figure 3-32: Step 4, A Practical Experiment with IMS-LD Level B

Advantages

- It is based on the IMS-LD Level B feature, with the learner's profile stored and saved in the Database.
- It is easier for the designer to change the individual learner's special requirements. The CSS file can be modified for each learner.

Disadvantages

- It is complex to achieve this configuration for each learner's profile.

- It is necessary to prepare the whole course material before it is zipped in the content package, including every feature to support the learner's needs.
- This lesson set-up is quite difficult and complex using the LD Editor and also the LD Player.

Step 5 Practical Experiment 3 (XSLT + JavaScript)

This next step is a practical experiment (*Figure 3-30*) which can help the designer to read the XML file within the IMS Learning Design specification (IMS-LD) Unit of Learning. It also avoids installing all the software, and makes it easy to read the contents of the learning design.

The developer has carried out a technical investigation of the use of the IMS Manifest file to make it more 'viewable' and accessible, using eXtensible Stylesheet Language Transformations (XSLT) technology.

This practical experiment has adopted multiple technologies, i.e., HTML, JavaScript, and XSLT. The HTML code provides the basic interface, and the JavaScript offers the process activity. The XSLT (Deitel *et al.*, 2001) is important in this experiment, because it integrates with the XML file, and selects the details from the XML file and presents it in the HTML page. The steps are illustrated in *Figure 3-33*.

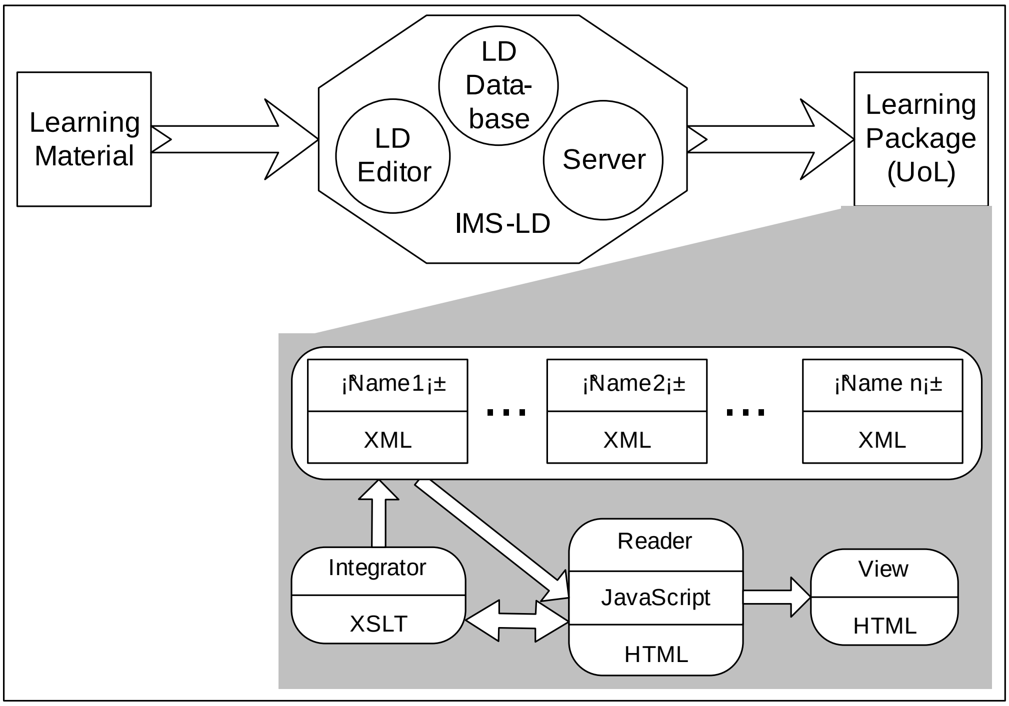

Figure 3-33: Step 5, XSLT Technology to Read the IMS Manifest (XML) File

Advantages:

This practical experiment has advantages for the IMS-LD developer, giving better insight into the internal XML structure, as follows:

- Reusable XSLT, XML, JavaScript and HTML allow the viewing of the Learning Design outline in the each learning package.
- It is easy for the designer to view and consider the elements of the Learning Design, under construction.
- This ‘view’ approach can be used for the entire IMS Manifest XML file.
- These simple pieces of XSLT and JavaScript code can be reused in other contexts throughout lesson development, to make the system internal details more accessible to the developer.

Disadvantages:

- There are still some technical limitations in using XSLT and the XML Manifest file.

In summary, Step 3 and Step 4 focused on the software tools and features of the IMS Learning Design specification (IMS-LD), including an analysis of the system environment and an evaluation of the features of the software tool-set. These two simple online course prototypes (steps) include the use of CSS and JavaScript technologies. Practical advantages and disadvantages have been outlined in each step. Step 5 of the practical experiment mainly provides the XSLT technology to examine the data (list of IMS elements) from the IMS Manifest file, to give the researcher better insight into the system XML hidden details.

3.5 Concluding Remarks

This context analysis involves experiments with the IMS Learning Design specification (IMS-LD) Levels A and B. The meta-level analysis of the IMS-LD capabilities has been investigated, the tool-set has been assembled and assessed, and initial prototype lessons for special needs have been tested for feasibility.

These steps were a necessary part of assessing the capabilities of the IMS-LD tool-set as well as the use of web technologies for the development of lesson prototypes. The researcher gained valuable experience and a good familiarity with the development tool-set. These practical experiments become more mature in the next steps of the research, as they were more fully designed and implemented, as detailed in the next chapter, Chapter 4: Meta-model and UoL Design.

4. Chapter Four: Meta-model and UoL Design

4.1 Design Introduction

For this project, the design document aims to provide the structure for implementing an e-Learning meta-model supported lesson, which is according to the IMS Learning Design specification (IMS-LD, 2003). Furthermore, it helps to investigate if the IMS-LD could be used for special education software. The lesson could be adaptive and suitable for assisting children with autism to learn, and is produced as a Unit of Learning (UoL).

In the project, the researcher has chosen a topic in mathematics for the special needs learner. The lesson objective is to teach the learner to understand the numbers from 1 to 5, and it also includes counting the objects using a variety of images. The design goal is to specify the necessary steps for the developer to build the practical lesson. There are three parts in the design section. They are the Meta-model Design, IMS-LD System Design, and Technology Design in this mathematics UoL.

4.2 Meta-model Design

4.2.1 *Introduction*

The meta-model design aims to produce a suitable meta-model (lesson structure) for special needs learning. This is relevant to the practice of online learning, which presents the learning objective, the learning content, and the learning activities.

The meta-model design provides a practical structure for how to implement the Prototype lesson content. This design plan includes the following parts, which are interface design for the IMS-LD environment, and meta-model structure design.

4.2.2 *Interface Design in IMS-LD*

The interface of the Prototype lesson is designed to work directly with the learner with autism. Based on Human-Computer Interaction (HCI) design principles (Preece *et al.*, 2002), the design of an interface could improve the quality and enhance the effectiveness of the learning content and objectives (Stone *et al.*, 2005).

However, the IMS-LD Player software offers the interface for general learners, e.g., *Figure 4-34*. It is the interface of the CopperCore LD Player. There are two navigation menu areas to the left, and the learning content field to the right (CopperCore, 2007). The LD designer can not change the interface of this LD Player.

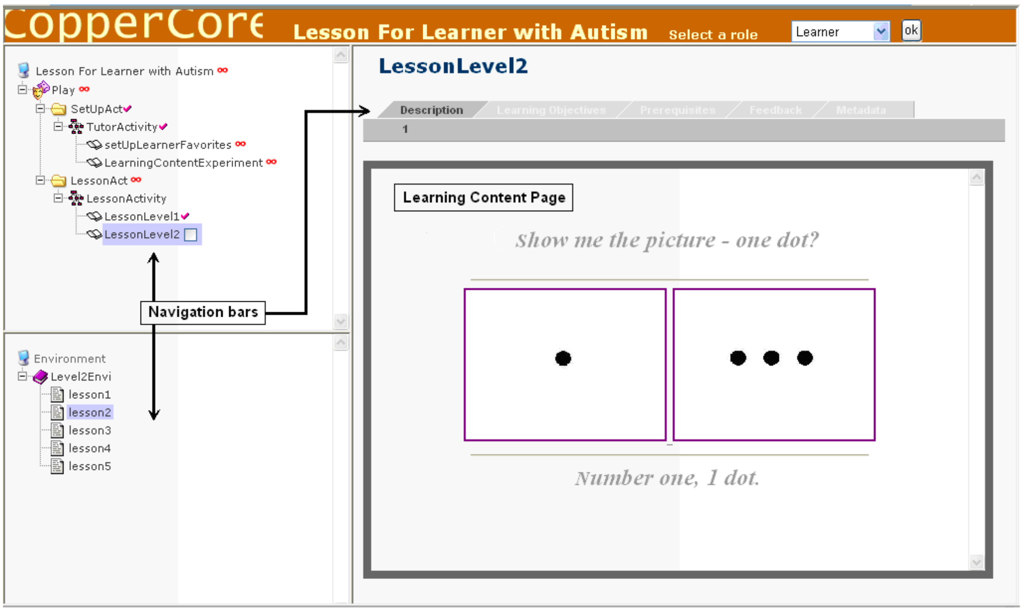

Figure 4-34: IMS-LD Player Interface (CopperCore)

Therefore, in this project we were constrained to work with the open source tools available. The IMS-LD Player used is not so readily adaptable for young learners with special needs.

4.2.3 *Lesson Content Interface Design*

The learning content interface design aims to build a suitable interface to support the special learning styles and to respond to the learning needs. The interface of the page should be built based on the learner's view (Howlin, 2002), and it presents the lesson interface as the screen shot in *Figure 4-35*. There are four parts in the learning content page. They are title field, images field, comment field (instruction and information), and border.

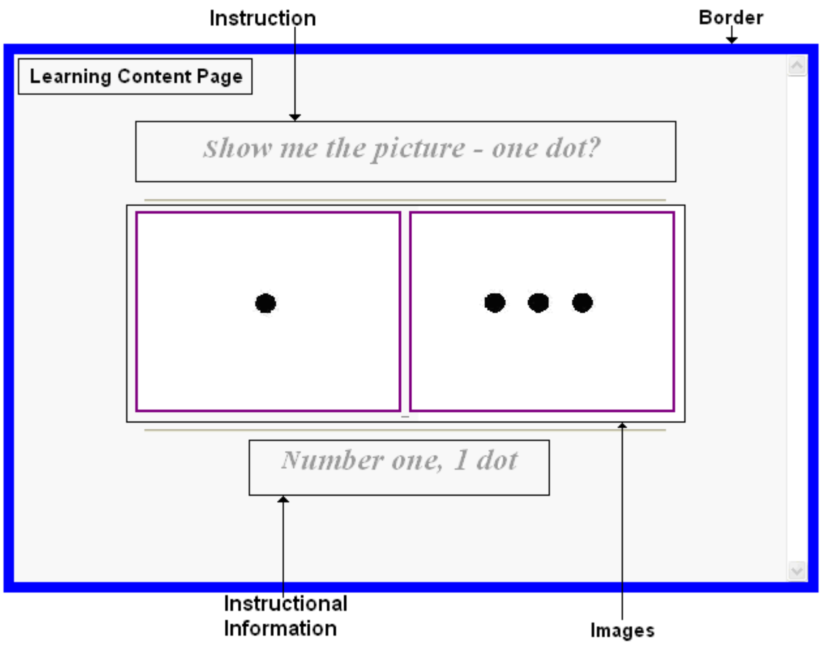

Figure 4-35: Lesson Content Interface

According to Pressman (2005) and Preece *et al.* (2002), there are basic rules for interface design, e.g., 'Place the user in control, reduce the user's memory load, and make the interface consistent.' The interface design also needs to be planned around the learning characteristics, described in the next section, i.e., offering simplicity, multimedia support, flexibility and colour.

Four Characteristics of Interface Design

Simplicity

The learner is a child who has autism, and he or she cannot accept too much information at one time (Howlin, 2002). Therefore, the designer should keep the lesson interface simple, with few words and not many images per page. The background is white in colour in the Prototype lessons, to avoid too much colour in the interface.

Multimedia support

Multimedia may help learners to learn, and keep them interested (Siegel, 2003). The screenshot, illustrated in *Figure 4-36*, shows the interface options in audio, border colour, text colour, and text style. These options provide many combinations, so that the Special Education Needs (SEN) tutor can configure the system according to each learner’s needs and preferences.

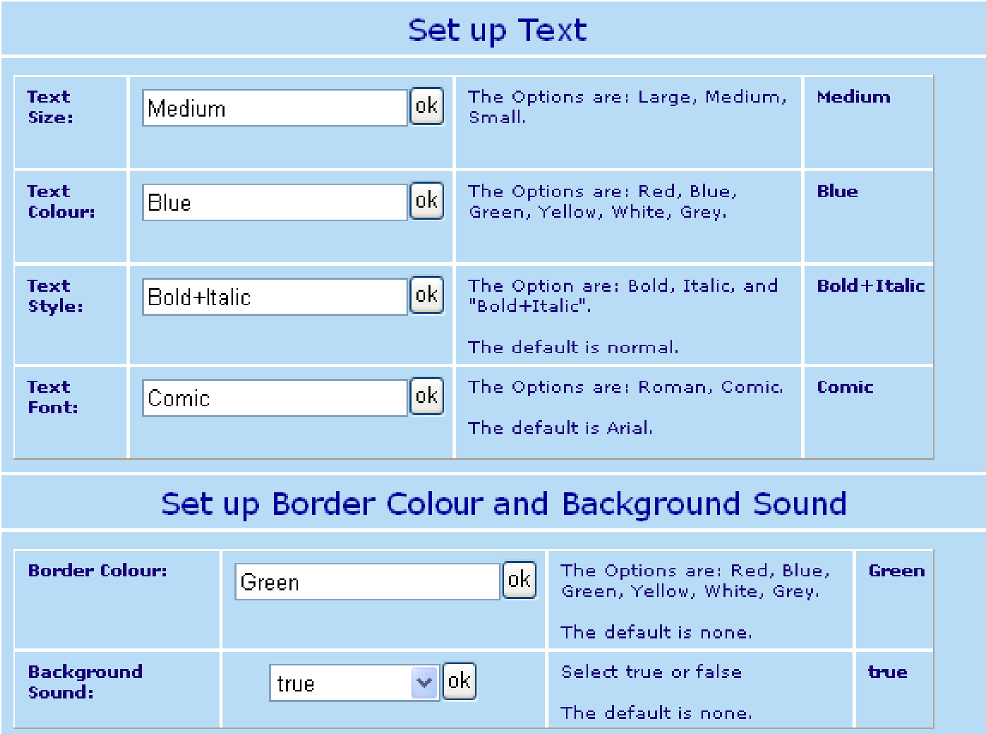

Figure 4-36: Text, Border and Audio Options

Flexibility

Based on the features of the IMS-LD (2003), the value of a Property can be changed each time a lesson is used. The SEN tutor can re-set the learner's profile. For example, if the learner does not like the colour red anymore in the web page, or the text font, then the tutor can change these at any time for the learner.

Colour

Colourful learning content pages also may enhance the learning (Siegel, 2003). The colour options are offered for background border and text. The SEN tutor could choose the colour from red, blue, yellow, green, white and grey. However, colours must be chosen carefully as some learners may not like certain colours.

4.2.4 *Meta-model Structure Design for the UoL*

As described in the previous chapter, we have investigated the basic IMS Learning Design specification (IMS-LD) model. During the experimental analysis, we found that the IMS-LD meta-model could be structured to suit the learner with special needs.

In order to achieve the research goal, the IMS-LD based Prototype lesson needs to be built as a Unit of Learning (UoL). Therefore, we need to adopt a set of special educational strategies, e.g., the reinforcement of the learner's motivation. The meta-model design can incorporate special learning strategies, e.g., musical interaction (Alvin and Warwick, 1991; Prevezer, 2000).

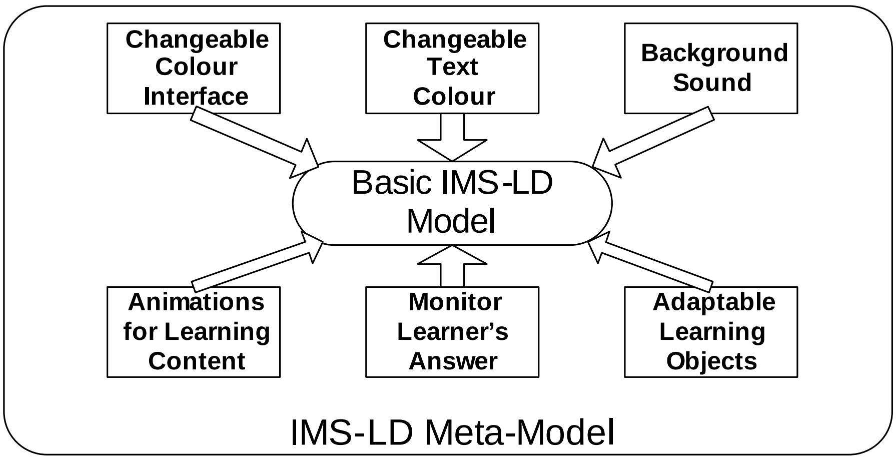

Figure 4-37: Adaptation of IMS-LD Meta-Model to suit SEN Learners

As illustrated in *Figure 4-37*, the meta-model should contain a changeable colour interface and learning text for each individual learner. The lesson could be adaptable, and the learner's answers could be monitored. The animation and background sound might be attractive for learners and hold their interest.

4.2.5 *Data in Meta-model Design*

To build the IMS-LD meta-model, there is an initial investigation of the data aspect of the system. In *Figure 4-38,* the meta-model data supports preference settings, to allow the SEN tutor to set up the learner's individual preferences, e.g. colour of text. The learner also has his or her general data, e.g., name and age. The third kind of data is the learner's response in the learning scenario, e.g., the answer to question 1. The learner's personal response data could be compared with global data to give feedback on a correct or incorrect answer.

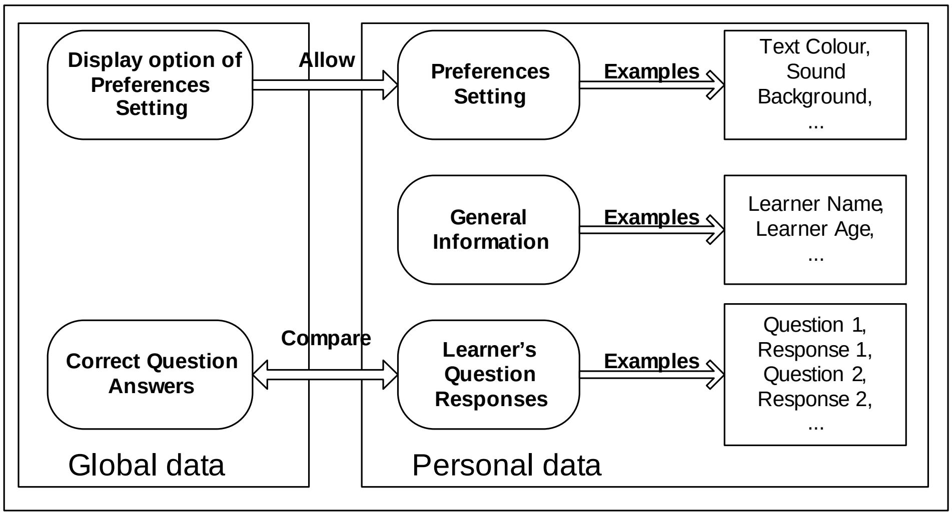

Figure 4-38: User data Aspects of the IMS-LD Meta-model

To summarise the meta-model design section, it is relevant to special education, with a pedagogical strategy for the learners with autism. This practical lesson needs more functions and choices for the learners that are monitored by the SEN tutors, e.g., choice of text size, background sound, and different learning activities. These functions may be achieved in the lesson implementation phase. In the next section, we discuss the meta-model in the IMS-LD system in detail.

4.3 IMS-LD System Design

4.3.1 *Introduction*

The aim of the IMS-LD system design is to design a suitable system process for the practical lesson, which is to produce the IMS-LD Unit of Learning (UoL). The system design provides the flow of the system activities. It also provides a limit within the boundary of the system. For these two system design goals, we describe the two subsections, which are the system data design and the learning activities design.

Furthermore, the IMS-LD Level B has been defined to provide the two main features, which are Property and Condition (IMS-LD, 2003). These features allow the system to store relevant information and render the dynamic learning activities.

As noted in Chapter 3: Analysis of the Research Context, the design phase is a bridge from analysis to implementation. *Figure 4-39* illustrates the design phase in the project development process.

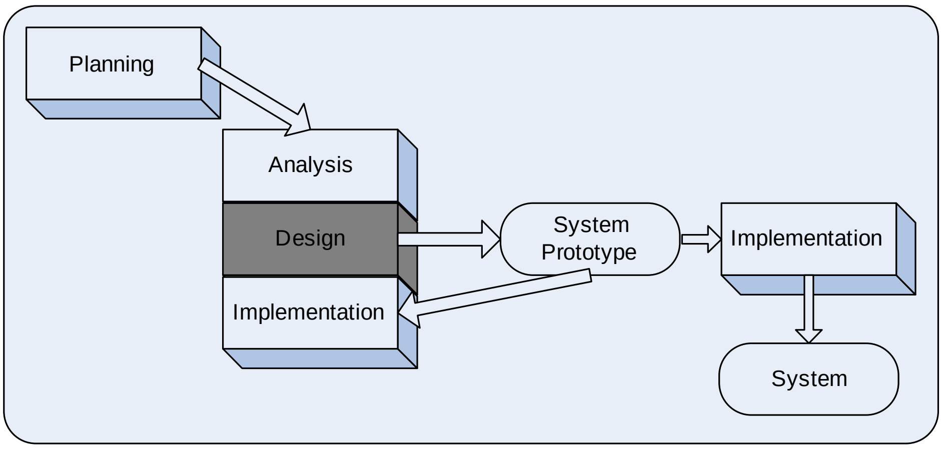

Figure 4-39: System Design Phase (redrawn from Dennis *et al*., 2004)

Unlike the analysis phase, the design phase is not focusing on describing the required data and function. It provides the model details about data structure, architecture, interface and components needed to implement the system (Pressman, 2005).

4.3.2 *System Data Design*

For the particular learner, he or she needs multiple choices and preferences for the lesson content. These data values relating to choices are stored and presented by IMS-LD features.

The data for the learner's information are:

- Learner Name (data value: String)
- Learner Age (data value: Integer).

The data values for the preferences are in String format. These data items are:

- Text Size (SmallText, MediumText, LargeText)
- Text Style (BoldText, ItalicText,BoldItalicText)
- Text Colour (RedText, BlueText, YellowText, GreenText, GreyText, WhiteText)
- Text Font (ComicText, NewRomanText)
- Border Colour (RedBorder, BlueBorder, YellowBorder, GreenBorder, GreyBorder, WhiteBorder).

The final data item is Background Sound (BgSoundTrue BgSoundFalse), and its value is Boolean. The user preference configuration data is shown in *Figure 4-40*.

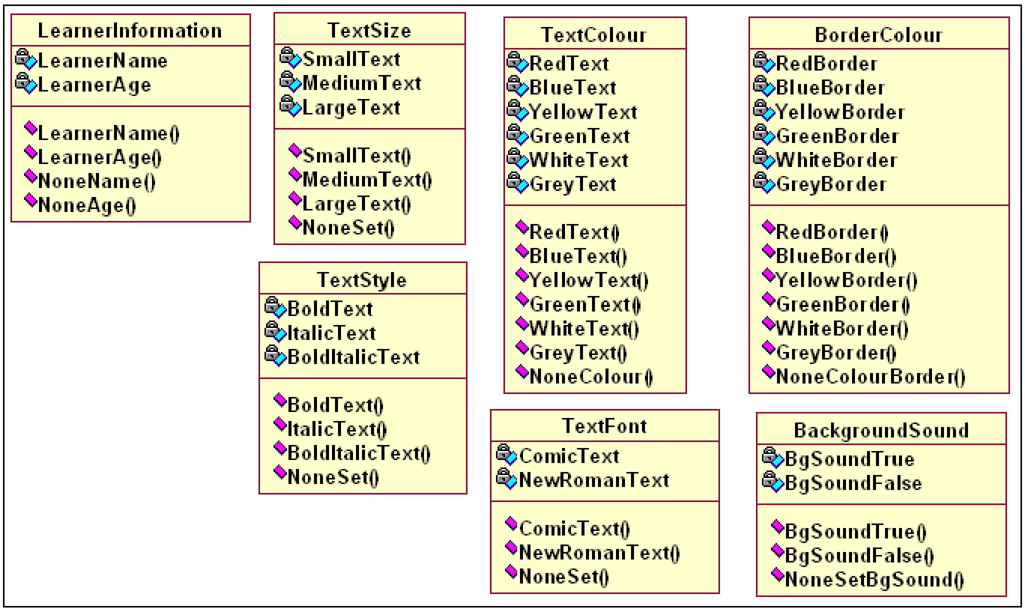

Figure 4-40: System Data Design

Many other user preferences would be possible but we have experimented with the subset shown. The IMS-LD Level B Property feature is described in the next section.

4.3.3 *Property Feature and System Data*

Using the Properties in LD

A Property is a system variable in the lesson environment, and there are four ways to use the Property, after it is defined. These four ways are set-property, view-property, set-property-group, and view-property-group, in the teaching and learning process. These are also called **Global Elements** (IMS-LD, 2003; Koper, 2005b).

The Properties can be used in the UoL as static or dynamic storages, as shown in *Figure 4-41*. The static and dynamic Properties can be effectively designed in LD and provide the LD features and services. For example, the Learner submits the initial answer as a dynamic Property, then the tutor makes a comment (static Property), and afterwards the learner may need to correct the answer.

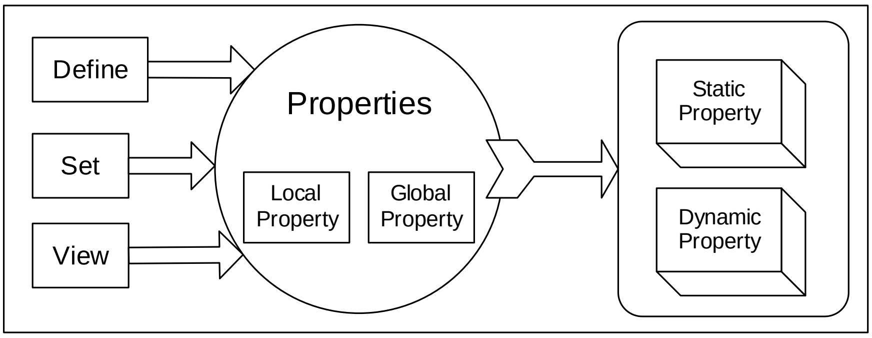

Figure 4-41: Designing Use of Properties

Next, we give more details on how the Properties are used.

Define Property

Before setting up the Property's value, the LD designer has to define the Properties, e.g., a Property's title, initial value, data type, or restrictions. The definition code is stored in the IMS Manifest file (Koper and Miao, 2007). The LD editing tool can generate XML code, automatically. The comparison is shown between the RELOAD LD Editor (RELOAD, 2006) and XML code in *Figure 4-42*. The Property could have the default value, once it is defined.

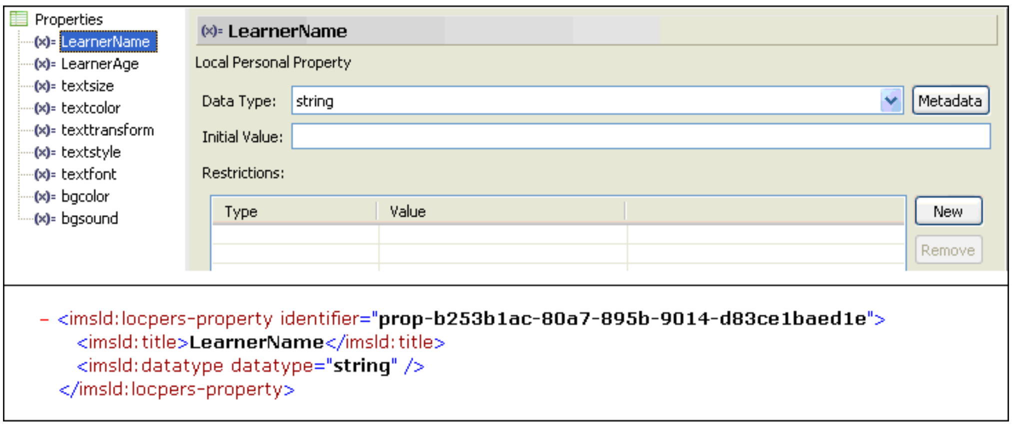

Figure 4-42: Comparison between the RELOAD LD Editor and XML Code

Set Property

When the UoL is running, the value of Property can be set in the web page (XML file), via the XHTML technology. The code for setting up a Property is in *Figure 4-43*. The lesson web page offers a text box for typing in the value for both learners and SEN tutors. The Property reference has to be consistent with how the Property was defined.

```
<ld:set-property ref="prop-b253b1ac-80a7-895b-9014-
  d83ce1baed1e" of="self" />
```

```
<ld:view-property property-of="self" ref="prop-b253b1ac-80a7-
  895b-9014-d83ce1baed1e" />
```

Figure 4-43: Set and View Properties in XML Code

View Property

As with set Property, view Property also uses the XHTML technology. The code for ‘Viewing Property’ is illustrated in *Figure 4-43*. The lesson page (XML) could show the Property’s value for the Role that has authority to access it.

To summarise on the Property feature of IMS-LD Level B: it provides dynamic system data, and stores personal information. It also combines with the Condition feature to support adaptive and collaborative learning (Koper and Olivier, 2004).

In this research project, the Property feature has been explored to accommodate to learning styles, and to produce the instructional prototype lesson. It also allows the system to collect and to present data from the learners and tutors. In the next section, the design focuses on the activities in the IMS-LD system.

4.3.4 *System Activities Design*

Within the system, the learning activities are used to create the system flows. To design these flows, the Unified Modelling Language (UML) diagram is used to represent the flows (Dennis *et al.*, 2004). The system processes support the two roles, which are the SEN tutor and the learners.

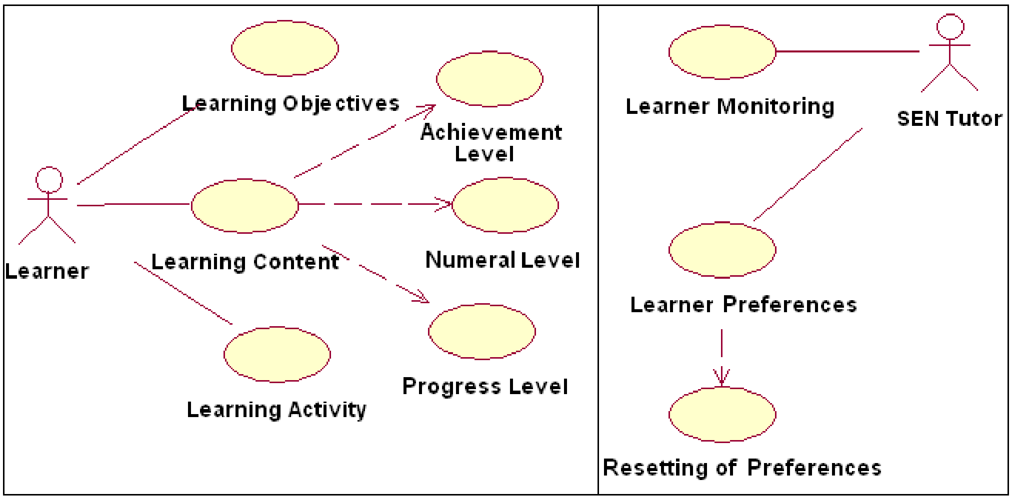

Figure 4-44: Use-Case Diagram, Learner and Tutor Perspectives

The SEN tutor's elements include the setting-up of the learner's preferences, the monitoring of learners and the re-setting of preferences if necessary, as illustrated in *Figure 4-44*. The learner's elements include the learning objects, i.e., learning content, and learning activities.

System activity design focuses on the flow of activities that are running in the system. As illustrated in *Figure 4-45*, the first activity route is that of the SEN tutor who sets up the IMS-LD Environment and sets up the learner's preferences. Then, the SEN tutor also may reset the preferences for a subsequent learning session, or exit the learning system.

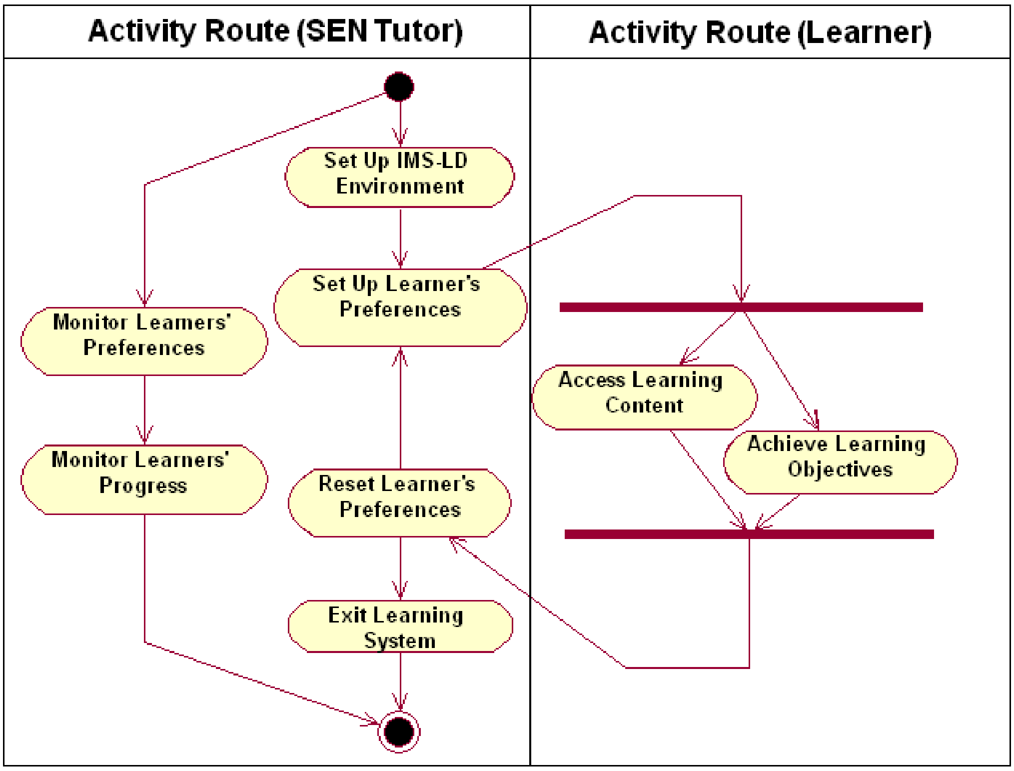

Figure 4-45: System Activities Design

The second activity route describes the set of learning activities where the learner accesses the learning content and may achieve the learning objectives. The IMS-LD Level B Condition feature is described in the next section.

4.3.5 *Condition Feature and System Activity*

Designing for the Condition Feature

The Condition feature can provide programming-style expression options as illustrated in *Figure 4-46*. The simple logical format on the left hand side evaluates the expression to produce the Condition for Learning Design. If the expression has been satisfied, then the Condition implements the actions. The 'list of Expressions and Conditions' screenshot (*Figure 4-46*) is from the RELOAD (2006) LD Editor.

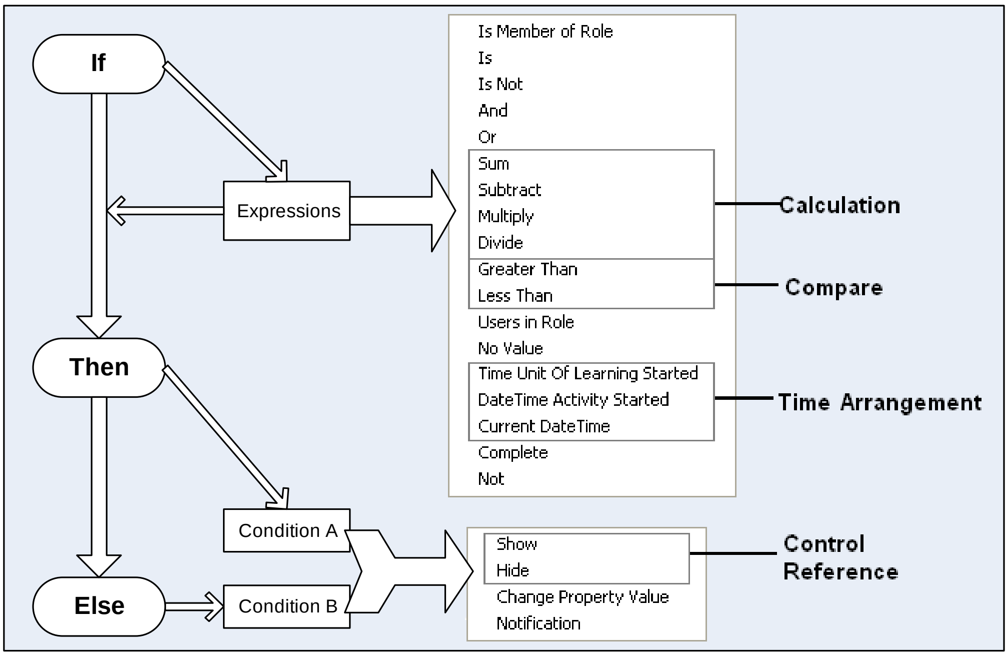

Figure 4-46: Conditions and Expressions in the RELOAD LD Editor

These LD expressions are effective in comparing or calculating the value of the Property, which in turn can be used to set a timer on learning responses (if wished) or trigger a new Role (Activity). Finally, they can change the learning process to show or hide interface elements, according to the learner's preferences, and they also can change the Property's value. For example, a preference could be a colorful learning text used to enhance the interface.

To summarise, the IMS-LD system design has been described in this section. It focuses on the activities design and data design in the system. The next section describes the technologies that support special needs learning in the development of the IMS-LD UoL.

4.4 Technology Design

4.4.1 *Introduction*

The technology design is the main support, which leads from the theoretical IMS-LD system design to the practical lesson design. It describes each of the web technologies adopted in the project. The web technology design is divided in two main parts. These are the three-tier approach design and the IMS-LD features design.

4.4.2 *Three-tier Approach*

The three-tier approach partitions the web (software) to help the developer to choose flexible web technologies to use in the system (Jia and Zhou, 2005; Larmann, 2002). This approach offers different views i.e., the Client, Application and Data tiers. These three tiers employ different web technologies, which are illustrated in *Figure 4-47*.

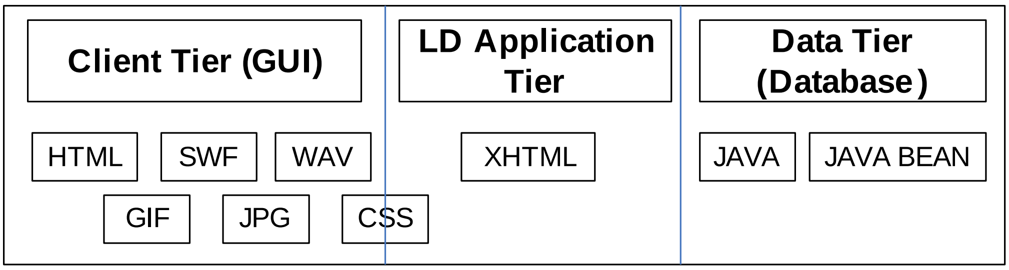

Figure 4-47: Design of Three-tier approach

First tier – Client Tier

The client tier is the Graphical User Interface (GUI) front-end for learners. The required technologies are the HyperText Mark-up Language (HTML) files, images, and multimedia. HTML is based on web technology to present the learning content in the web page. The images include both the Joint Photographic experts Group (JPG) and Graphics Interchange Format (GIF) format. The images could help the learners to count graphical numbers and understand the recognised numbers. Multimedia includes audio and Flash technologies. The audio is in Windows Audio (WAV) format; the Flash is in ShockWave Flash (SWF) format. These provide learners with sound and animation, making attractive the learning objects and helping with reinforcement. The reinforcement could respond to a special needs learner's answer, as shown in *Figure 4-48*.

Figure 4-48: Encouraging Feedback

Second tier – The LD Application Tier

The application tier is used to connect the other two tiers, and act as the application between them. For example, the features of the IMS-LD can store the learners' information and manage the learning session. The technology can be presented by the eXtensible HyperText Mark-up Language (XHTML) within the LD code. The Cascading Style Sheets (CSS) technology is used to configure the learners' interface elements and link the GUI to the LD application, as shown in *Figure 4-49*. CSS files are invoked when a Condition is triggered, and a change of interface is required, thus linking the GUI to the learning environment.

Figure 4-49: An Instruction in the Lesson Interface with Colour Blue

Third tier – Data Tier

The data tier is important in the system. The data is stored by the IMS-LD Engine software in a hidden back-end system database. This software is built by the Java and Java Bean technology (CopperCore, 2007). While the CopperCore LD Engine is 'open source' and available, the internal database structure is not accessible for modification by the LD designer or user.

The three-tier approach introduces each web technology used in the project. The next section describes how the web technologies integrate with the IMS-LD environment.

4.4.3 *Technical Design of IMS-LD Features*

The IMS Learning Design specification (IMS-LD, 2003) Level B provides two features (Property and Condition), which offer services, such as storing learners' information in a Property variable, triggering learning activity by a Condition, and monitoring learners (Koper and Burgos, 2005).

To design the lessons, the researcher adopted CSS and XHTML web technologies. The process is illustrated in *Figure 4-50*. The learner's information is stored in the LD Engine, by XHTML technology. It offers a form for options about the learner's information, e.g., text colour. The CSS files include the different effective interfaces that are triggered (Croft *et al.*, 2006; Teague, 2007).

Figure 4-50: CSS and XHTML Technology Design

The monitor feature is used to evaluate every learner who uses a Unit of Learning (UoL). The design idea is that if a SEN tutor logs in using the tutor Role, then the IMS-LD provides features for choosing the option to view each learner's information and progress.

CSS offers the possibility of configuring a personalised interface for each user, as illustrated in *Figure 4-51*.

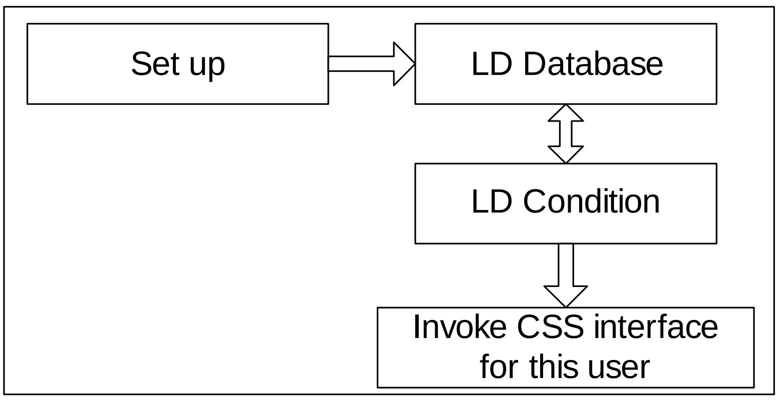

Figure 4-51: Personalisation Support

This personalisation implementation detail is illustrated further in *Figure 4-52*.

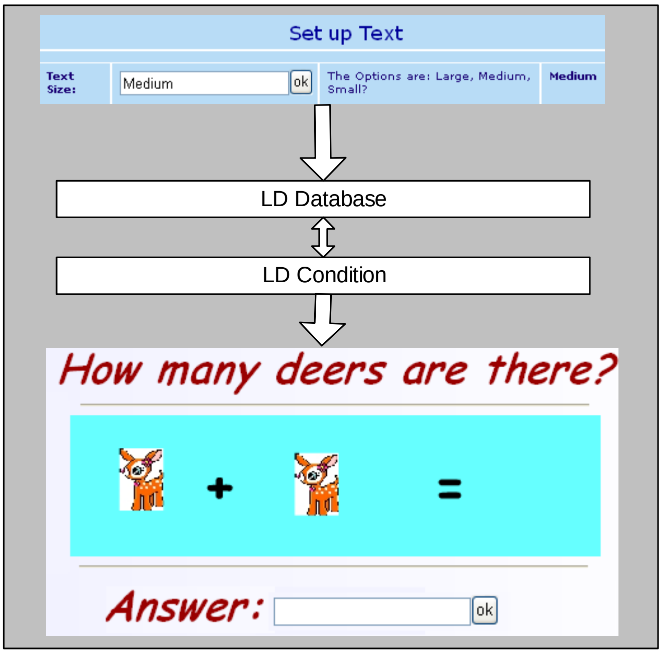

Figure 4-52: Personalisation Example

To summarise this section, the technologies in this project are the web technologies integrated with the IMS-LD software to implement the meta-model design. They work together to present an entire IMS-LD based online practical lesson. While designing and developing with these technologies, it was found that it could produce suitable course material for learners with special needs. It allowed flexible configuration for different learning needs, for example, different font size, font colour, and background sound, as well as supporting the monitoring of the learner's progress.

In the following section, the implementation phase is described.

4.5 UoL Implementation

The implementation phase is the project system process that comes after the design phase, as presented in *Figure 4-53*. The implementation phase has two outcomes, which are to finally produce the lesson, while allowing a return to the design phase if needed, as part of the iterative process. During the implementation phase, the actual system is built (Dennis *et al.*, 2004). Therefore, the prototype Unit of Learning (UoL) is built, and also may be redesigned, until the final suitable prototype is achieved.

Figure 4-53: System Implementation Phase (redrawn from Dennis *et al.*, **2004)**

In this research project, the implementation phase produces the prototype lesson (UoL). *Figure 4-54* shows Step 6 and Step 7 in this system development process. The description of the prototype lesson is in the following section.

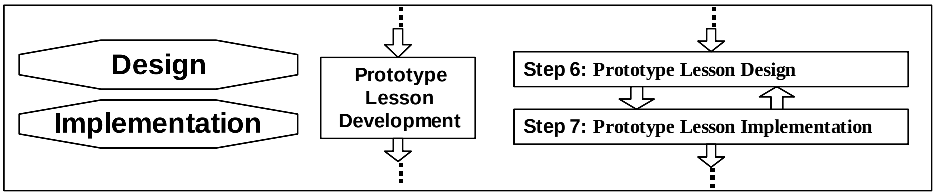

Figure 4-54: Step 6 and Step 7, Prototype Lesson Design and Implementation

4.6 Prototype Development

There are two main aspects to the prototype lessons, which are the Design and the Implementation in each case. As described earlier, the prototype might be re-designed and re-implemented many times, until there is a satisfactory prototype (Dennis *et al.*, 2004). There are some prototype lesson screen shots, which are to show the interface of the lesson content, in Appendix A: Prototype Screenshots.

The researcher has developed the prototype lessons, so that they focus on different aspect of learning. As shown in *Figure 4-55*, for each prototype lesson, the researcher designed and implemented it gradually. The details of these prototype lessons are described in the following sections.

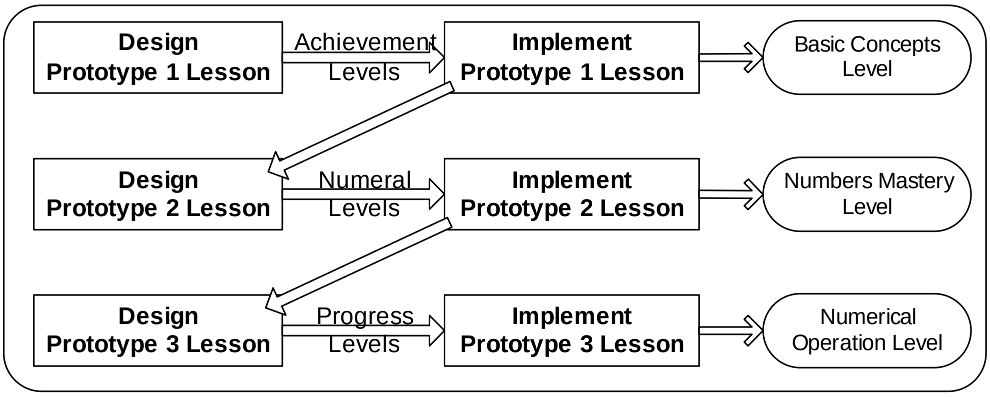

Figure 4-55: Prototype Lesson Development Steps

As shown in *Figure 4-55,* the investigation has focused on configuring the LD environment for learner ‘Achievement Levels’ in Prototype 1, for ‘Numeral Levels’ in Prototype 2, and for learner ‘Progress Levels’ in Prototype 3.

4.6.1 *Prototype 1*

Learner Achievement Levels

In order to develop a lesson that might be appropriate for special needs learners, the researcher divided the entire lesson content into three achievement levels. These are basic level, medium level, and advanced level. These three levels were divided, based on learners’ understanding of mathematics in accordance with the National Council for Curriculum and Assessment (NCCA, 2002). They are described in the following paragraphs, and the basic points are illustrated in *Figure 4-56*.

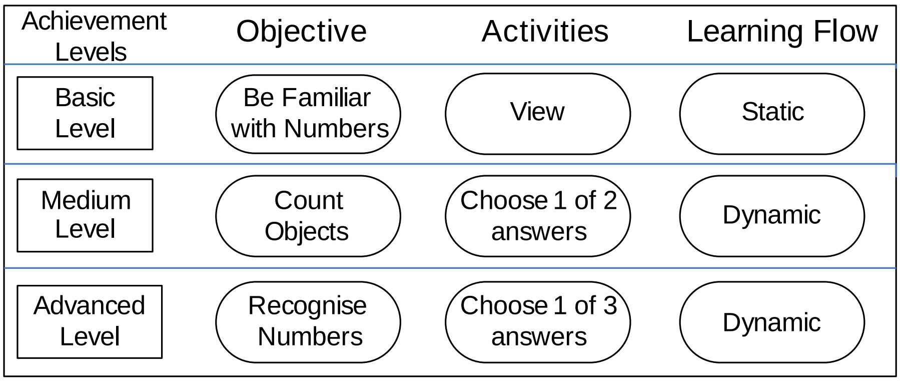

Figure 4-56: Prototype 1, Learner Achievement Level Design

Basic level. The basic level is the simplest level for the group of learners. These young learners may not easily accept mathematical concepts initially, and they may not know the meaning of numbers (Powell, 2000). The learning objective is to view the sequence of numbers and graphical objects. The goal of this level is to make learners familiar with the number and objects representing the value of that number, e.g., the number 2 beside an image of two cats (NCCA, 2002).

Medium level. This is more advanced than the basic level. It is a comparison between two graphical objects, e.g., to choose (click) one correct image, and to answer a question. The goal of this level is to count the objects.

Advanced level. This is a more advanced level, being harder than the other two levels. It requires the learner to select the number, by selecting the correct image from the three images presented. The goal of this level is to know and recognise the number.

These three levels provide a process for the learner to advance from the basic level to the advanced level. Within each stage, there is a different learning objective. This instructional strategy can provide an increasing challenge for an individual learner, and also the sequence of learning content has been provided from easy to hard as recommended by the curriculum guidelines (NCCA, 2002).

Learning Content

Prototype 1 is the initial prototype lesson in this research project. As described in its design section, it focuses on the learning content for special education. There are also three achievement levels for the special needs learner. Prototype 1 has implemented the CSS technology to describe each learner's learning page interface, in order to provide personalisation at the interface level.

The audio, CSS, and image files are included in all three achievement levels. However, the medium level and advanced level accept responses from the learner. The image and Flash materials support the 'reinforcers' page, when the correct answer is given. The learning material's implementation description is shown in *Figure 4-57*.

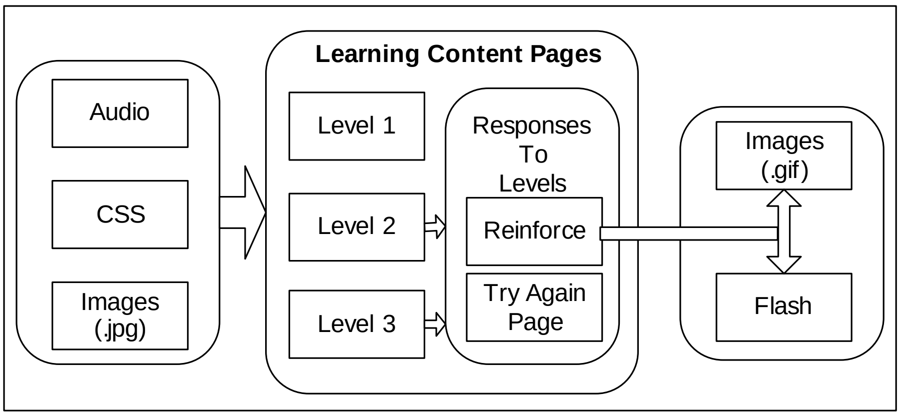

Figure 4-57: Prototype 1, Learning Materials Implementation Description

Figure 4-58 shows the interface of Prototype 1.

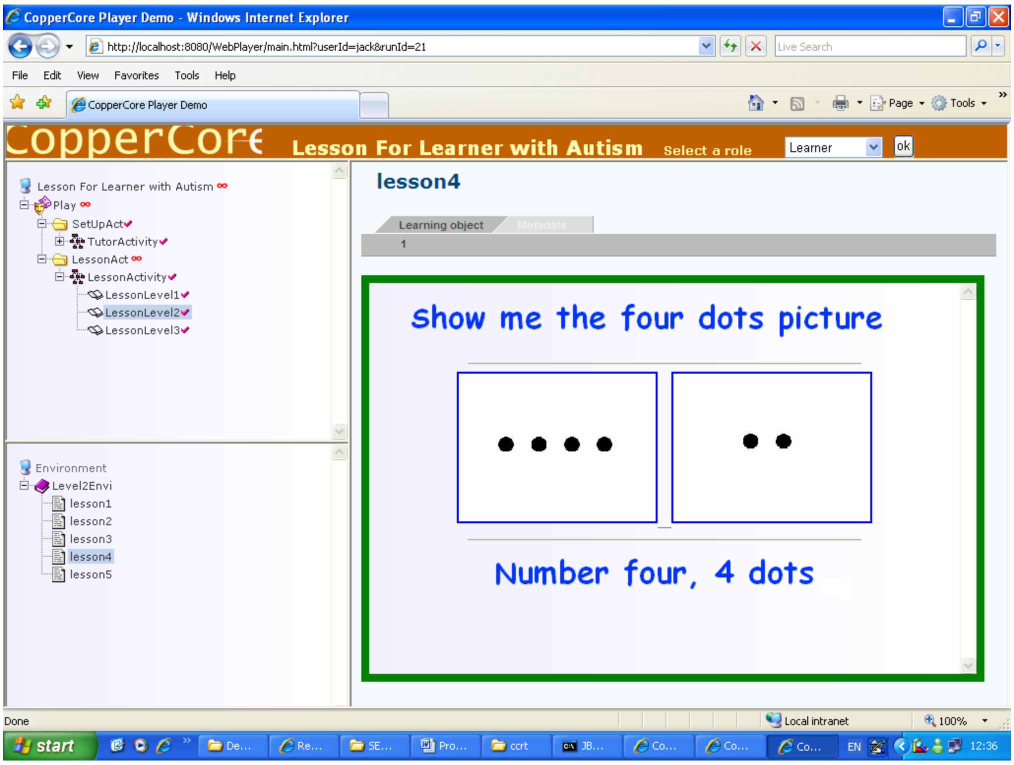

Figure 4-58: Prototype 1, a Screenshot of the Lesson Content

There are further sample Prototype 1 interface screenshots in Appendix A: Prototype Screenshots. They show Prototype 1 in its practical run-time, and also illustrate the learning material files (pages) which are:

- Lesson Content
- Reinforcers (to motivate and engage the learner)
- The monitor function page.

Prototype 1 has a drawback. It is that the Condition and Property features have not been used enough. Therefore, the IMS-LD features are not fully explored. So, the next iteration of the prototype should provide a more suitable lesson. The design ideas are documented in the next section.

4.6.2 *Prototype 2*

Numeral Levels

Prototype 2 was designed to be based on Prototype 1 so that it retains the benefits of the interface design used already. Prototype 2 adheres to the NCCA (2002) curriculum guidelines, as did Prototype 1. It includes practice in addition and subtraction with numbers in the range 1 to 5 (Horstmeier, 2004). Each lesson section (or level) for a particular number (e.g., 3) provides reusable activities that can be repeated until the concepts are mastered. *Figure 4-59* illustrates this numeral level design.

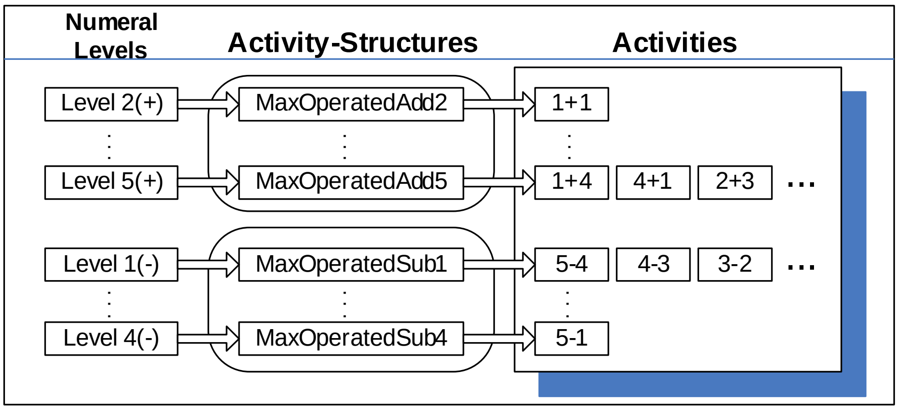

Figure 4-59: Prototype 2, Lesson Numeral Level Design

Prototype 2 design ideas are based on both of the features Property and Condition, which are provided by IMS-LD Level B. After the SEN tutor sets up the level (number and operation, e.g., addition) as Properties, then the Condition feature evaluates the Properties, to show or hide the relevant activity structures.

Learning Content

Prototype 2 is focused on learning and repetition using the IMS-LD Level B features to provide a simple calculation lesson. The lesson shows the learner the calculations

Addition and Subtraction within the number range 1 to 5. Prototype 2 has been produced as an adaptive learning scenario that helps the learner with Addition or Subtraction. The Unit of Learning (UoL) is adaptive to each learner's needs. The SEN tutor can decide on:

- Addition or Subtraction
- The range of numbers to use between 1 and 5
- The number of activities to carry out.

The system, via the Condition feature presents the required learning activities for each learner in a personalised manner, as shown in *Figure 4-60*.

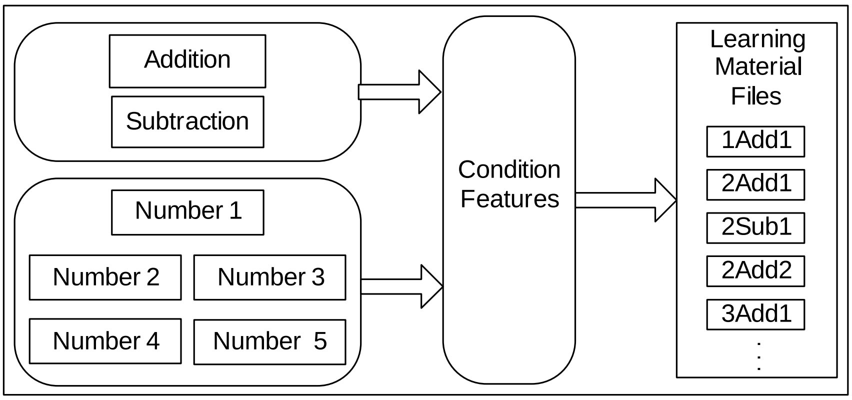

Figure 4-60: Prototype 2, Learning Materials Implementation Description

A drawback of Prototype 2 is that it is weak on learning management, because it focuses on providing a particular practice for learners, but not in 'question and answer' mode. So, Prototype 3 is designed for the learners, who can use the computer more competently. *Figure 4-61* shows the interface of Prototype 2.

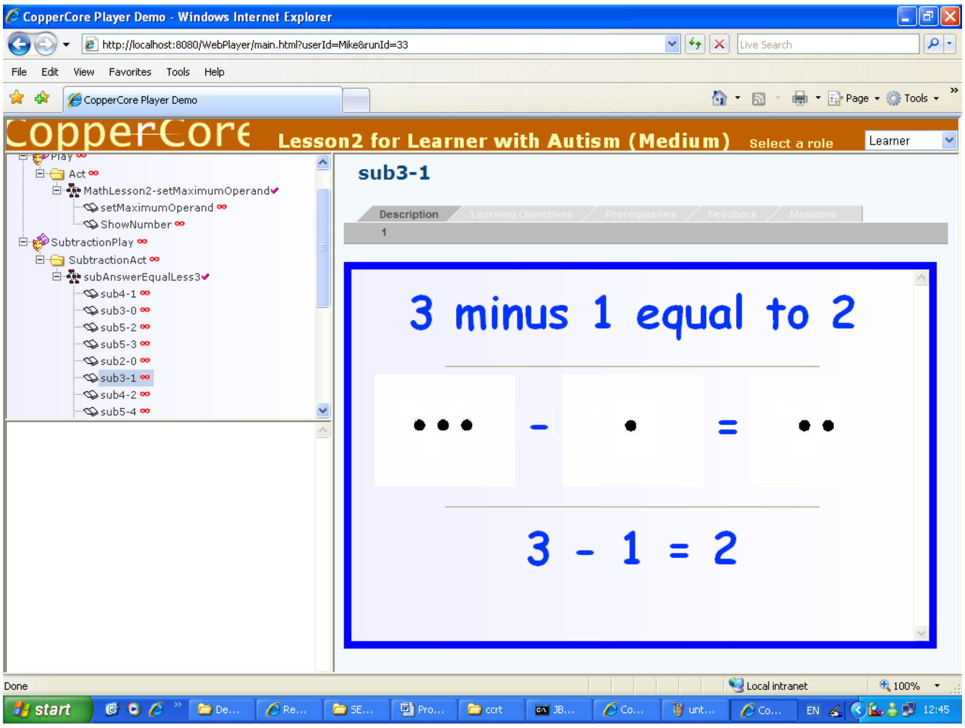

Figure 4-61: Prototype 2, a Screenshot of the Lesson Content

4.6.3 *Prototype 3*

Learner Progress Levels

Prototype 3 is designed for the learner, who may engage in more 'question and answer' type interaction. It aims to improve upon the previous prototype lessons by allowing the learner to progress through levels of difficulty (Horstmeier, 2004; NCCA, 2002), as illustrated in *Figure 4-62*.

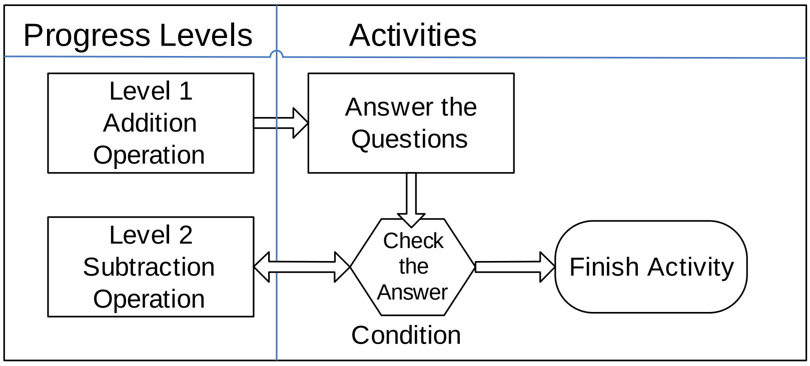

Figure 4-62: Prototype 3, Design Progress Levels

The main lesson content is divided into two levels, which are based on two operations, addition and subtraction. The learners can engage in question and response dynamic interaction. This implementation adopts the IMS-LD Level B Condition and Property features more fully than Prototype 2.

The Property feature holds the value of the addition operation level, and then the Condition feature can check the value to provide a reward (allow the learner to accumulate ‘stars’). Then the learner can progress to the subtraction operation level. The details of Prototype 3 are described in the next section.

Learning Content

Prototype 3 works with the IMS Learning Design Level B features (Property and Condition). In its basic structure it is similar to the previous prototype lessons. The lesson includes two perspectives, one for the SEN tutor and one for the learner. The tutor needs to set up the learner’s preferences first and then to monitor the learner’s learning results and progress. The learner types in the correct number as an answer, and needs a good level of computer literacy to complete a learning scenario. Learners need to be given guidelines when first using Prototype 3.

Prototype 3 is developed from both Prototypes 1 and 2, e.g., re-using Prototype 1’s learner preference set-up system and Prototype 2’s separate operations (addition or subtraction). The learning content of Prototype 3 includes the addition and the subtraction learning pages for the learner. The SEN tutor could manage the learner’s preferences for the learning interface. These activities are illustrated in *Figure 4-63*.

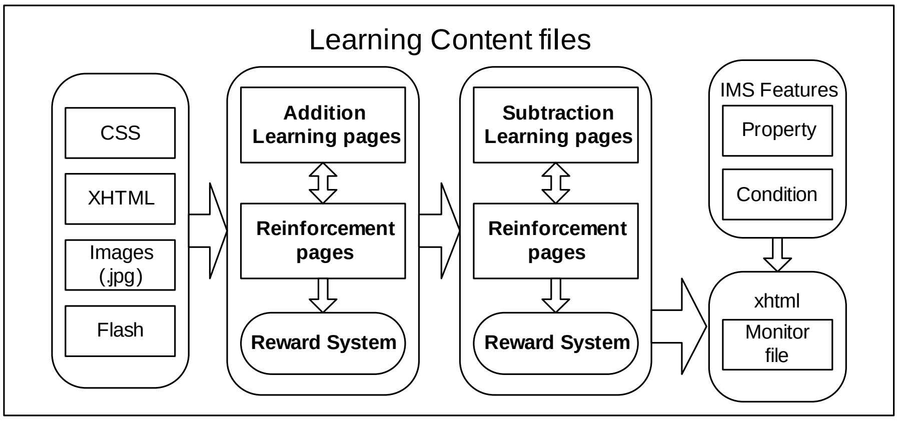

Figure 4-63: Prototype 3, Learning Materials Implementation Description

The most important improvement is that the Flash files and image files are adopted to add animation to the learning content. So, the learner might engage with the animations during the learning scenario. Furthermore, the Property is used to record the learner's answers and provide the Condition for progress to the next learning level, as shown in *Figure 4-64*. Further sample screenshots are provided in Appendix A: Prototype Screenshots.

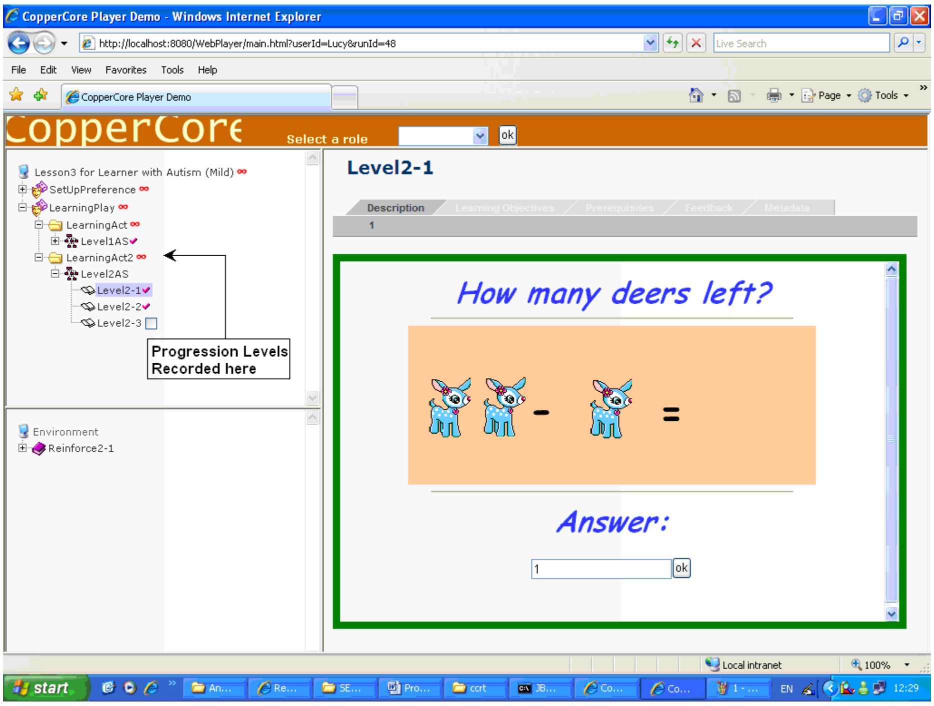

Figure 4-64: Prototype 3, a Screenshot of the Lesson Content

4.6.4 *Prototype Development Summary*

The three prototype lessons (UoLs) have adapted the IMS-LD Level B features to provide the pedagogical outcomes and enhancements to satisfy the special needs of learners. Web technologies have been used to support and construct the learning content web pages. The details of the three prototype lessons are listed in Table 4-2.

Table 4-2: Three Prototype Lessons Support the Learner's Special Needs

Prototype Lesson	IMS-LD Prototype Features	Web Technologies	Pedagogical Outcome	Learning Enhancement
Prototype 1 lesson	Set up learner's preferences.	CSS, JavaScript and XHTML	The learning material can be changed.	Interfaces are personalised.
	The answer to a question can be checked.	HTML	Question and test integration.	The learning objective is assessed.
	Multimedia has been included in the prototype lesson.	Image, Flash and Audio	Provide engaging learning material.	Attractive interface with animation.
Prototype 2 lesson	Exploring IMS features - Property and Condition.	XHTML	Manage content sequencing	Provide a logical sequence to help learners to learn.
Prototype 3 lesson	Improve upon user's preferences and personalise the learning path.	XHTML, Flash	Motivate learners to do more activities.	Animation to support understanding, encouragement and rewards.

To summarise the implementation phase, the prototypes have been produced incorporating a progression in design ideas, learning levels, uses of IMS-LD features, and supporting technologies.

4.7 Concluding Remarks

In summary, there are three subsections in this chapter to describe the system, the technologies and the practical lessons. The three subsections also describe the design from a logical, technical, and physical viewpoint.

This incremental approach has assisted the researcher in structuring the production of the lessons. Each prototype lesson has been produced as a complete UoL according to the IMS Learning Design specification.

The next chapter (Evaluation) documents the evaluation phase, i.e., the activities relevant to testing the prototypes and evaluating the outcomes.

5. Chapter Five: Evaluation

5.1 Evaluation Introduction

The evaluation phase is the last phase in the project development process, as illustrated in *Figure 5-65*. Outcomes are evaluated, feedback is obtained and the Prototype is re-worked to address the shortcomings.

Figure 5-65: Step 8, Evaluation in the Project Process

The prototyping-based methodology (Dennis *et al.*, 2004) indicates that the evaluation provides valuable feedback, so that improvements may be implemented.

A heuristic evaluation (Nielsen, 1993) method has been selected. As defined in Chapter 2: Literature Review, heuristic evaluation is a usability engineering method for indentifying usability problems. Therefore heuristic evaluation could inform the researcher on relevant aspects of the IMS Unit of Learning (UoL).

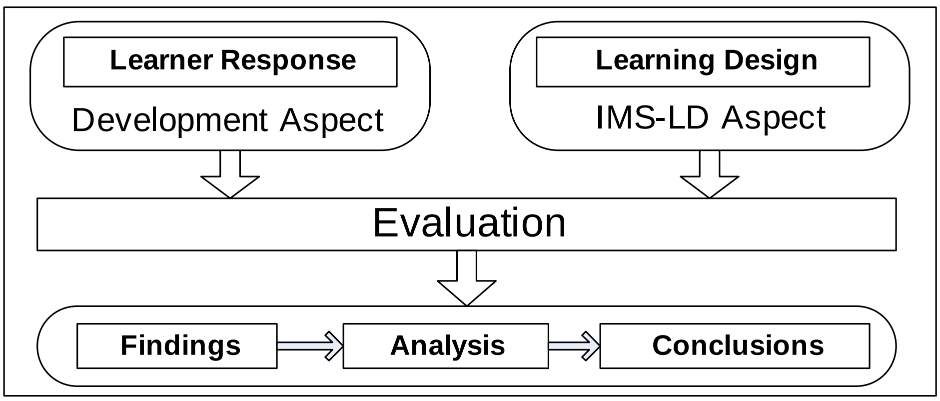

Figure 5-66: Overview of the Evaluation

As illustrated in *Figure 5-66*, the evaluation phase for the present investigation aims to assess two aspects to of the research project. These are:

- Development aspects (development and lesson evaluation)
- IMS-LD environment aspects.

Evaluation sessions evaluate user interface design and investigate usability requirements (Stone *et al.*, 2005). The evaluation strategies have been decided and documented to focus on usability and to suggest improvements to the prototype lessons. The inspectors (an expert user group) tested the IMS-LD based prototype lesson individually. A questionnaire and additional comments were filled in after each inspector's test. The data has been collected and analysed.

5.2 Evaluation Framework

The evaluation has focused on (a) Learning flow, (b) Interface elements and (c) Course content, in order to assess the overall effectiveness of the IMS Learning Design (IMS-LD) approach. *Figure 5-67* illustrates an evaluation framework based on the ISO 9126 standard (first published in 2004) (ISO/IEC, 2008), as follows:

- The dynamic learning flow designed by the IMS-LD, is evaluated.
- The interface of the courseware, supported by multimedia (sound and images), and CSS web technology (text font, size and colour) is evaluated.
- The course content, which aims to satisfy the accessibility and learnability requirements, is evaluated also.

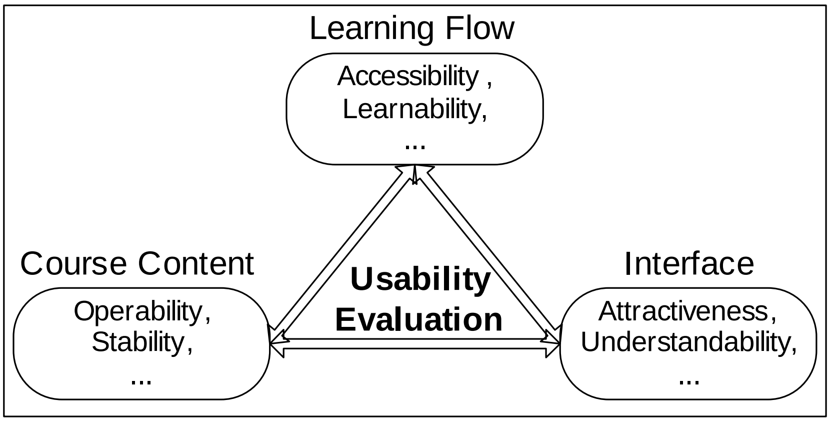

Figure 5-67: Evaluation framework (adapted from Chua and Dyson, 2004)

These components (Chua and Dyson, 2004) are examined by an expert user group who evaluate the prototype lesson. IMS-LD features are assessed for their applicability to special education support, from a technical point of view. The questionnaire was based on the evaluation framework. The details of the questionnaire are in the next section.

5.3 Evaluation and Questionnaire

The questionnaire aimed to examine the prototype lesson, and to evaluate its usability at run-time. Responses were collected and analysed. The evaluation sessions were planned according to guidelines for expert user group evaluations, according to Stone *et al.*, (2005).

The evaluation documents (guidelines and questionnaire) are provided in Appendix B: Evaluation Session Documents. By evaluating at two levels, i.e., two roles, evaluators got insight into (a) the course management potential and (b) the learning experience on offer in the IMS-LD environment. The evaluators carried out two roles, i.e., that of (a) the SEN tutor and (b) a learner. The researcher had set up these two roles for each of 8 evaluators before each session.

5.3.1 *Evaluation Session*

For the evaluation sessions, the researcher invited 8 expert users, experienced in multimedia and online learning, as the inspectors. The researcher set up the IMS Learning Design (IMS-LD) run-time environment. Then the inspectors used the prototype lesson (UoL). They were provided with instructions on how to use the environment and which tasks to carry out. The guidelines document 'Background Information' (Document 1) is provided in Appendix B: Evaluation Session Documents. The following is an outline of the evaluation session:

- Each session lasted 45 minutes
- Two evaluators attended at one time
- Two laptops were provided in a research laboratory for the session
- Each evaluator used the lesson, completing the tasks outlined in the 'Summary of Evaluation Tasks' (Documents 2 and 2a), included in Appendix B: Evaluation Session Documents
- The researcher was present to observe and assist if required
- Each evaluator completed a questionnaire having first used the lesson
- Evaluators were asked to add further comments.

Four sessions, as described above, were carried out on two consecutive days in January 2008. The questionnaire had ten questions, based on ten categories. Each question had five levels of agreement, according to a 5-point Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree). A copy of the questionnaire (Document 3) is included in Appendix B: Evaluation Session Documents.

The ten questions covered the following system aspects: Ease of Configuration, Operability, Ease of use, Multimedia, Personalisation, Dynamic aspects, Suitability, Attractiveness, Understandability, and Learning Potential.

5.3.2 *Questionnaire Results*

On the whole, the inspectors were satisfied with the IMS-LD prototype lesson. The results of the questionnaire are described below. In the following paragraphs, we list the categories of questions, and present the evaluation results.

Question 1, Ease of Configuration: *The IMS Lesson environment is easy to configure.*

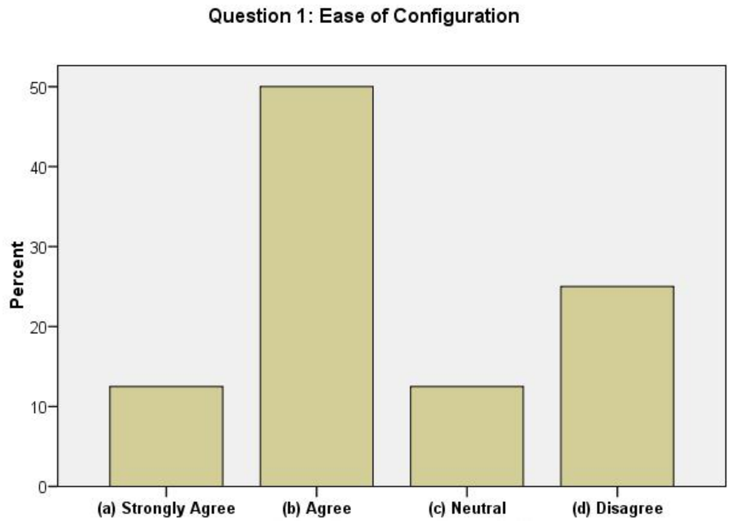

Figure 5-68: Level of Agreement on Ease of Configuration

The results, illustrated in *Figure 5-68*, indicate that:

- 12.5% strongly agreed with this statement
- 50% of evaluators agreed
- 12.5% were neutral
- 25% of evaluators disagreed with the statement.

These results show that a majority of evaluators considered that the system was easy to configure, with 25% disagreeing.

Question 2, Operability: *The IMS-LD based prototype operates well at run-time.*

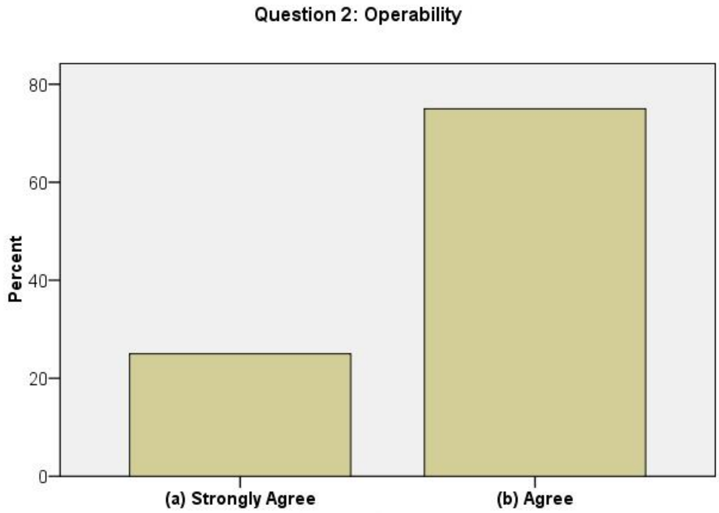

Figure 5-69: Level of Agreement on Operability

The results illustrated in *Figure 5-69*, indicate that:

- 25% strongly agreed with this statement
- 75% of evaluators agreed.

These results show that all evaluators agreed that the Prototype operates well at run-time.

Question 4, Multimedia: *The multimedia helps the learner to understand the lesson.*

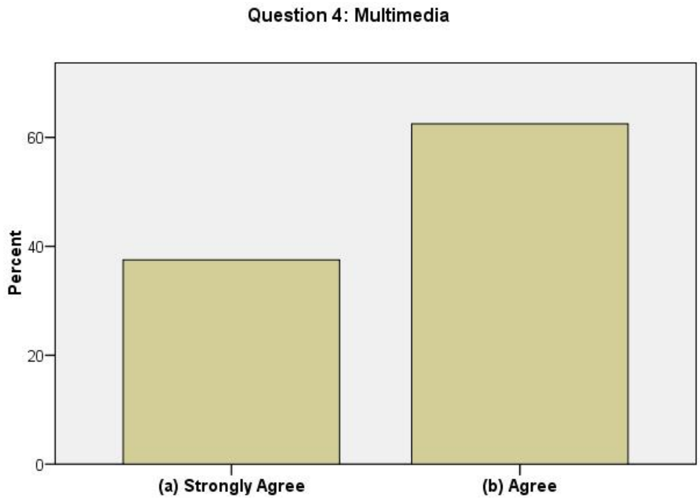

Figure 5-70: Level of Agreement on Multimedia

As illustrated in *Figure 5-70*, the results indicate that:

- 37.5% strongly agreed with this statement
- 62.5% of evaluators agreed.

These results show that all evaluators agreed that the multimedia helps the learner to understand the lesson.

Question 5, Personalisation: *The level of personalisation (Individual Preferences) is satisfactory.*

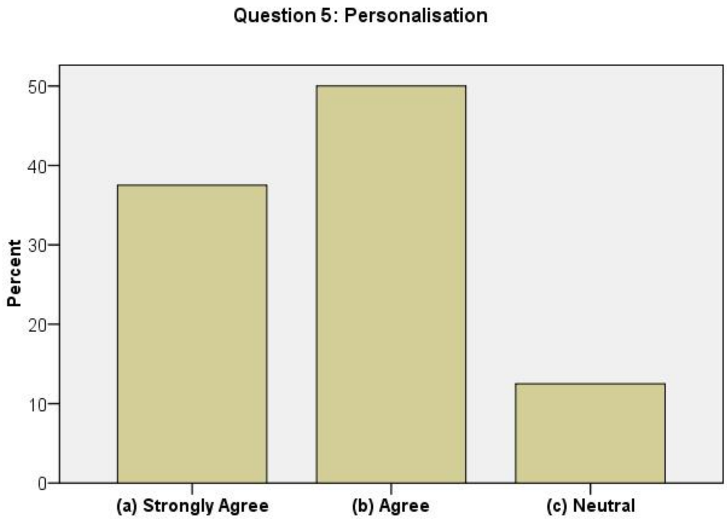

Figure 5-71: Level of Agreement on Personalisation

The results, illustrated in *Figure 5-71*, indicate that:

- 37.5% strongly agreed with this statement
- 50% of evaluators agreed
- 12.5% were neutral.

These results show that a majority of evaluators considered that the level of personalisation (Individual Preferences) is satisfactory.

Question 7, Suitability: *The lesson provides appropriate feedback on error.*

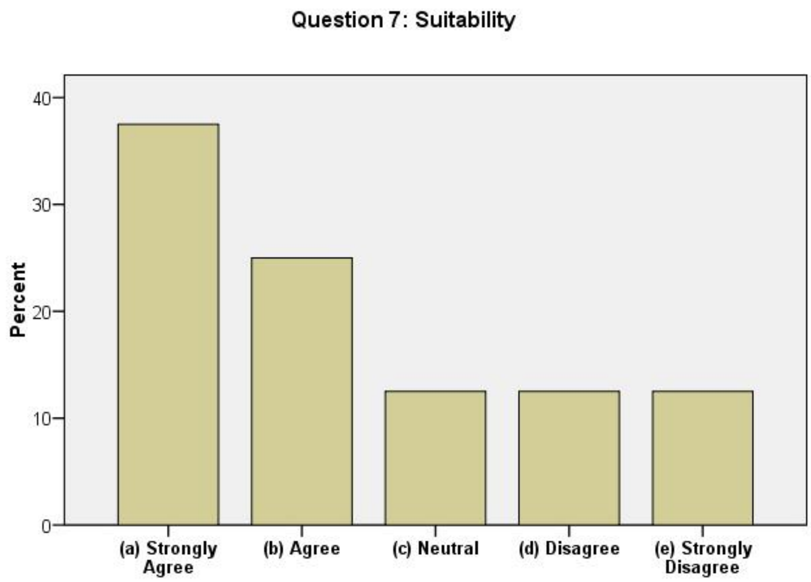

Figure 5-72: Level of Agreement on Suitability

The results, illustrated in *Figure 5-72*, indicate that:

- 37.5% strongly agreed with this statement
- 25% of evaluators agreed
- 12.5% were neutral
- 12.5% of evaluators disagreed
- 12.5% strongly disagreed with the statement.

These results show that the evaluators considered, by a slight majority, that the lesson provides appropriate feedback on error.

Question 10, Learning potential: *Learners could learn from this IMS-based mathematics lesson.*

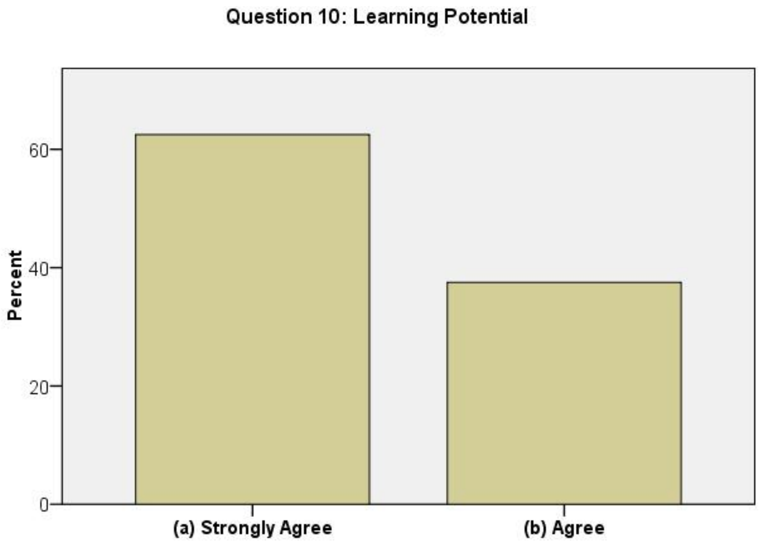

Figure 5-73: Level of Agreement on Learning Potential

The results, illustrated in *Figure 5-73,* indicate that:

- 62.5% strongly agreed with this statement
- 37.5% of evaluators agreed.

These results show that all evaluators agreed that the learners could learn from this IMS-based mathematics lesson.

The remaining results are summarised next, and the SPSS output for all 10 questions is included in Appendix C: Statistical Tables.

Question 3, Ease of use: *This prototype lesson is easy to use.*

The results indicate that:

- 12.5% strongly agreed with this statement
- 50% of evaluators agreed
- 25% were neutral
- 12.5% of evaluators disagreed with the statement.

These results show that a majority of evaluators considered that the prototype lesson is easy to use.

Question 6, Dynamic aspects: *The learning flow to complete the learning task is well structured.*

The results indicate that:

- 50% strongly agreed with this statement
- 12.5% of evaluators agreed
- 37.5% were neutral.

These results show that a majority of evaluators considered that the learning flow to complete the learning task is well structured.

Question 8, Attractiveness: *The prototype lesson interface is attractive for learners.*

The results indicate that:

- 50% strongly agreed with this statement
- 37.5% of evaluators agreed
- 12.5% were neutral.

These results show that a majority of evaluators considered that the prototype lesson interface is attractive for learners.

Question 9, Understandability: *The learner can understand the learning content in the lesson.*

The results indicate that:

- 50% strongly agreed with this statement
- 37.5% of evaluators agreed
- 12.5% were neutral.

These results show that a majority of evaluators considered that the learner can understand the learning content in the lesson.

(The output for this analysis, in SPSS frequency table format, is included in Appendix C: Statistical Tables.)

5.3.3 *Additional Comments*

The inspectors also provided additional comments, regarding (a) the personalisation facility and (b) drawbacks of the IMS-LD environment. A sample 'Additional Comments' sheet (Document 4) is included in Appendix B: Evaluation Session Documents. These comments have been analysed and are illustrated in *Table 5-3*.

Table 5-3: The Additional Comments from Inspectors

Aspects	Details	Percentage
	Re personalisation	
Personalisation potential	Personalisation was well presented via the individual learning interface.	75%
Using the system	The system is easy to use (once guidelines are provided).	37.5%
	Re IMS-LD Environment Drawbacks	
Complicated learning flow	Navigation is complex for a child with special needs.	62.5%
IMS framework weakness	Setting up of preferences needs a dropdown menu rather than typing in the input.	37.5%
Interface limitation	The lesson content space is small, and should be enlarged.	25%
Not familiar with the system	A little bit difficult for first time users, especially a user from a non-technical background.	25%
	Other Comments	
Feedback response unsuitable	A more immediate feedback response is needed once a question is answered.	62.5%
Interface	There is a good graphical interface.	25%

5.3.4 *Improvements after Evaluation Process*

With regard to the negative comment, 'Feedback response unsuitable: a more immediate feedback response is needed once a question is answered', the researcher has implemented changes in the programming of Prototype 3.

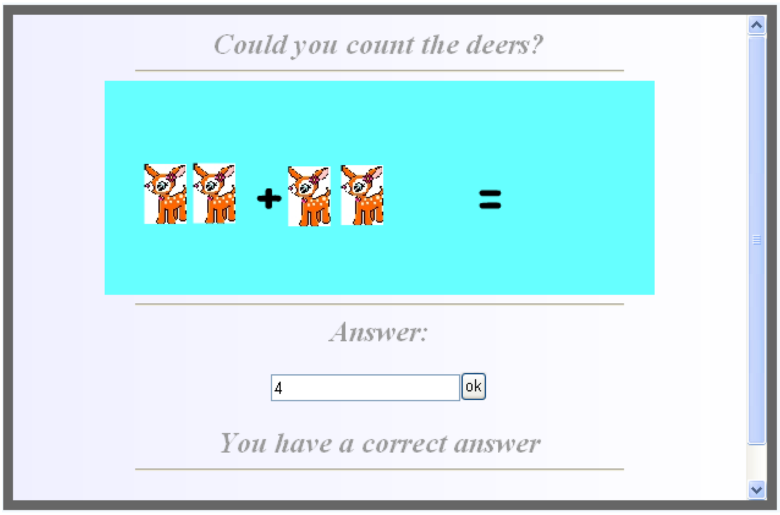

Figure 5-74: Response for Correct Input

Now (in Prototype 4) there is immediate feedback on each user input, as illustrated in *Figure 5-74* and *Figure 5-75*.

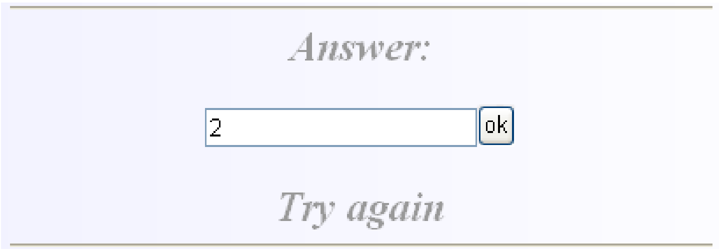

Figure 5-75: Response for Incorrect Input

The researcher has experienced conflict in some system variables in attempting to address the negative comment, ‘Complicated learning flow: navigation is complex for a child with special needs’. This aspect is discussed further in Chapter 6: Conclusion.

For other negative comments (section 5.3.3: Additional Comments) the implementation period needed to improve on these aspects would be quite lengthy and outside the scope of the present study. However they have been documented here as desired improvements.

5.3.5 *Observation of Evaluation Sessions*

The researcher observed the evaluation sessions and noted the user difficulties or problems with the system. These observations are documented in *Table 5-4*, showing that some evaluators experienced operational difficulties.

Table 5-4: Results of the Researcher's Observation in Evaluation Sessions

Aspects	Details	The percentage of inspectors
Operational mistake	User made a mistake in using the system.	50%
Complex operation	User had difficulty in progressing to next step. (e.g., asked for help)	50%
Navigation not clear	User did not understand the navigation mechanism.	37.5%
System conflict	Browser conflict between Firefox and IE in the IMS-LD environment.	25%

To summarise the overall results of the evaluation session, the inspectors mostly agreed that the IMS-LD prototype lesson could provide suitable learning material for learners with autism to support their special needs.

There were however some comments that indicate that the IMS-LD can prove to be a complex environment and needs user training. Tutors from a non-technical background would find it difficult to set up and operate it. In the next section, we evaluate the IMS-LD environment, from a technical perspective.

5.4 Assessment of the IMS-LD Environment

The assessment of the system that follows is based on the researcher's experiences throughout the project development and implementation. It aims to evaluate the IMS Learning Design meta-model features and also the IMS Learning Design software tools.

5.4.1 *Features in Meta-model*

The IMS-LD Level B features (Property and Condition) are adopted in Prototype 1, Prototype 2 and Prototype 3. These three Prototypes investigate and experiment with the IMS-LD meta-model. These features, which can provide services for learners and tutors are:

1. Monitoring: The system provides normal VLE features for monitoring student progress, but the tutor role is well structured.
2. Personalisation: The meta-model provides a personal digital portfolio to contain personal information. It also can provide for the personal learning activity or learning style and thus support the learner's special needs.
3. Assessment: This meta-model uses the learner's 'set Property' process, to gain feedback comments from the learners. This activity could collect results after the learner's learning activity, so that the learner's reflection (or feedback comments) could be collected by the tutor. This feature is probably more suited to older learners.

The result of this evaluation is that the meta-model could provide suitable online lessons for special needs education. The meta-model prototype lesson can incorporate special aspects and services for learners.

5.4.2 *Tools used in IMS-LD Development*

While the IMS-LD specification was published in 2003, the tools to implement it have been evolving only gradually since then (Koper, 2006). For example, the common tools in use in this investigation are:

- CopperCore LD Engine, a run-time environment for running a UoL.
- SLeD LD Player to support the CopperCore Engine, providing a user interface.
- RELOAD LD Editor and Player, an editing environment for lesson development.

The researcher has reflected on their usage, and the perceived advantages and drawbacks are listed in *Table 5-5*.

Table 5-5: IMS-LD Software Tools Evaluation

Name	Advantages	Examples	Drawbacks	Examples
CopperCore LD Engine	Sets up the whole IMS-based VLE, and runs the UoL	Validate a UoL	Web technology limitation	The web links can not be used in the XML page, and the learning interface frame can not be changed
SLeD LD Player	Provides a visible view for adding Roles (Learners)	Create Roles	Web technology limitation	CSS technology can not be supported
RELOAD LD Editor	A full tool set to edit, produce and re-edit a UoL	Produce UoL	Complexity in use	May not be easy to use for first time user
RELOAD LD Player	Helps manage the UoL at run-time	Delete Role	Weakness at run-time	Needs to work with the LD Engine at run-time

An advantage of the IMS-LD system is that it has its own validator to ensure all files are correct. The main checkpoints are listed here:

- The RELOAD LD Editor can check all ‘methods’ and ‘components’ in the content package, before it exports the UoL.
- The CopperCore LD Engine can validate the UoL, before uploading it, e.g., an image in the content package that is present but not needed, will be notified.

- Data validation is provided for input fields, e.g., a string, or integer data mistake is notified to the user.

Part of the complexity in building the development environment and using it is due to the research and experimental nature of the tools used. The tools have been produced by a variety of research projects and groups, as illustrated in *Table 5-6*:

Table 5-6: IMS-LD Tools, Research Groups, and Projects

Tools	Group	Project	Duration
CopperCore LD Engine	Open University of the Netherlands (OUNL) UK Open University	- Alfanet - D4LD (JISC)	- May 02 – April 05 - May 06 – October 07
SLeD LD Player	UK Open University Liverpool Hope University, UK Open University of the Netherlands	- D4LD (JISC) - UNFOLD	- May 06 – October 07 - January 04 – December 05
RELOAD LD Editor and Player	University of Bolton, UK University of Strathclyde, UK	- X4L strand B (JISC)	- June 02 – September 06

These projects are now finished and no further updates for the tools are released. These tools have been investigated in the present study to produce a suitable prototype lesson for learners with autism. During the evaluation of IMS-LD software tools, we found that these tools could build a learning environment, however they still have limitations in their use, causing some conflicts with web technologies.

5.5 Concluding Remarks

In summary, the advantages and disadvantages from a technical and practical view point of the IMS Learning Design specification (IMS-LD) have been presented. The IMS-LD meta-model can provide support for personalisation. It provides an instructional environment for online learning.

Each tool in the tool set assembled for the project had its own strengths and weaknesses. The tools used complement each other, to offer a full development environment, but they required considerable technical investigation and experimentation, to produce the prototype.

6. Chapter Six: Conclusion

6.1 Introduction

In this chapter, the results from evaluation sessions are presented. There are advantages and disadvantages with the IMS Learning Design specification (IMS-LD) for learners with autism. The research findings are discussed. Future developments for this area of research are also considered. In the following section, the research objectives are discussed and revisited to check the achievements of the project.

This project can be described as having firstly worked in a bottom-up approach, investigating the components and features of the IMS-LD techniques and tools. This allowed the researcher to become familiar with the specification, its possibilities and the available tools.

Then, in a top-down manner, a learning scenario to teach mathematical concepts was developed, putting into practice the understanding that had been gained earlier.

This approach, both bottom-up and top-down, has been identified also by Sodhi *et al.* (2007) as an appropriate means of working with a new specification and its tools.

6.2 Objectives Revisited

These research objectives have been revisited, as noted in Chapter 1: Introduction:

- A suitable pedagogical meta-model (prototype lessons) has been built and used to provide additional descriptions for learning objectives, to make educational software more acceptable and effective in use.

- The IMS-LD Units of Learning (UoLs) have been created as software learning scenarios, based on the pedagogical meta-model, to support the learner's special needs.
- The meta-model has been evaluated by an expert user group with a background in web technologies and teaching experience.
- During the evaluation session (testing the software prototype), the evaluators' feedback comments have been collected and later analysed. The findings are discussed in the next section.
- Dissemination has taken place at conferences and seminars.

6.3 Findings

In this section, the research focuses on features of the IMS-LD, which are from the evaluation sessions, and the technical investigation and development experiences. The status of current ongoing investigations is then discussed.

6.3.1 *Findings from the Evaluation Sessions*

Appropriate for young learners

The main challenge in the research project is that the IMS-LD specification is a novel approach in this educational field. It is unfamiliar to tutors, and would require a clear explanation of the methodology to the SEN tutors in ASD classes. Evaluation by an expert user group has highlighted that personalised learning is suited to learners with special needs and autism, to support their learning styles.

Complexity

Evaluation feedback has also indicated: ‘navigation is complex for a child with special needs’ (as described in Section 5.3.3: Additional Comments, and Section 5.3.4: Improvements after Evaluation Process). Members of the expert user group all had a technical background but, as shown in *Table 5-3*, the researcher noted that the IMS-LD system proved quite complex for them to operate.

As the evaluators’ feedback has shown, the IMS-LD is not easy to use for the first-time user. It would therefore be more difficult for a user from a non-technical background. The learners with autism could be confused with the navigation menu area. They may not understand how to operate the flow of learning activities without assistance.

This is confirmed by Burgos *et al.* (2007b) as follows: ‘However, current tools do not allow for an easy editing of rich and flexible UoLs. They make the creation of adaptive UoLs technically possible, but too difficult for a non-technical user.’

Technical Challenges

The IMS-LD could provide a personalised meta-model (as in the prototype lessons) for an individual learner, but, the technical challenges are still present. For example, the learning content interface is quite small for a learner, and it can not be enlarged to satisfy the learner (see a disadvantage noted in *Table 5-3*: Interface limitation).

6.3.2 *Findings from the Technical Investigation and Development*

Compatibility with other eLearning standards

The IMS can integrate with the SCORM (Sharable Content Object Reference Model) standard by using the Shareable Content Objects (SCOs), which are normally web pages incorporating some JavaScript code. The IMS-LD learning content pages can be in a variety of formats, including XML, and (X)HTML. This integrated experiment can be run in RELOAD SCORM 1.2 Player under CopperCore framework (Tattersall *et al.*, 2006), and a SCORM package can integrate with Moodle completely (Costagliola *et al.*, 2006)

With regard to the IMS-LD and Moodle VLE, in the present study the researcher has found that the latest version of Moodle (v 1.9) can support an IMS-LD lesson at Level A, but Level B support for multiple roles is not yet feasible in Moodle. These findings were also reported by Burgos *et al.* (2006b).

In a final experiment the researcher verified that Moodle version 1.9 can successfully run an IMS-LD content package (UoL) with Level A content. A screenshot illustrating this experiment is included in Appendix D: Recent Compatibility Experiments.

However a similar experiment for an IMS-LD UoL with Level B Properties, Conditions and Services was not successful, due to ongoing research needed at this level, as also indicated by Burgos *et al*. (2006b). A screenshot illustrating the researcher's experiment is included in Appendix D: Recent Compatibility Experiments.

New IMS-LD Editor Software Environment

The IMS Learning Design development environment is complex too, as confirmed by Burgos *et al.* (2007b), for example: ‘A higher level layer with a more visual metaphor is still missing, although on its way. The TENCompetence Project, for instance is developing a visual LD Editor.’ This might result in easier-to-develop eLearning material for users who do not have a technical background. Attractive interfaces might be provided for learners using newer tools than those available for the present study.

However, there are also some other challenges for the IMS-LD. For example, the software is difficult to adapt for special education purposes. It is not widely used yet in industry.

6.3.3 *Current Investigations in the eLearning Industry*

TENCompetence

In recent times, the researchers in OUNL are focused on a new project called ‘TENCompetence’ (2008). This project is still researching aspects of the IMS-LD. The TENCompetence Report, D6.1, (2008) indicates that the new LD authoring component software ‘ReCourse’ has been developed, which is based on the RELOAD LD Editor. The ReCourse LD Editor can edit and save IMD-LD UoLs at Level A but not at Level B or C yet. Furthermore it provides a graphical representation of IMS-LD elements. Therefore, it is easier to use than the Reload LD Editor, for the tutor without a technical background.

IMS/GLC Update

Also the IMS-LD has been supported and published by the IMS Global Learning Consortium (IMS/GLC, 2008). As Abel (2008) declared in the IMS/GLC quarterly board meeting (7th February 2008), 'IMS is still collaborating with industry to provide a learning impact. There are two key elements: Interoperability and Best Practice that enable effective use of learning technologies in industry.' There is also an IMS Common Cartridge (2008) project group that aims to achieve a formal specification, a standard package, and support for access protection of the IMS UoL in use.

Games Development and IMS-LD

There is ongoing research into games development, which is also based on the IMS-LD approach (Burgos *et al.*, 2006a; Burgos *et al.*, 2007a). It may provide a more suitable learning interface for learners, with the possibility of developing games suited to special needs and autism.

6.4 A Final Reflection

The researcher has investigated and developed the IMS Learning Design specification (IMS-LD) and its meta-model for learners with autism. The IMS-LD Level B features and services have been adapted in the UoLs. The evaluation results indicate that the IMS-LD has advantages that could be used for special needs education. It is expected that the IMS technical challenges and limitations will be solved by ongoing research.

As the results of the questionnaire illustrate, the personalisation and adaptable interface has been successful in providing for special learning styles. Through the ongoing research of the IMS/GLC and the TENCompetence project, the IMS-LD specification has learning potential into the future.

On a personal level, the researcher has achieved the following:

- A modern eLearning specification has been employed and integrated with web technologies, adding to the researcher's skills set in software development.
- The researcher has had the opportunity to attend quarterly summits on the IMS-LD specification, in the OUNL, Heerlen, Netherlands (9^{th} November 2006), and in the California State University, Los Angles, USA (6^{th} February 2008).
- The researcher has also made a poster presentation at the International Ed-Media Conference, Vancouver, Canada (27^{th} June 2007), and also has an upcoming paper presentation at the International Ed-Media Conference (3^{rd} July 2008), Vienna, Austria, see Appendix E: Publications. Regular presentations were also made, throughout the project, to other postgraduate students and the members of the WeLearnT eLearning Technologies research group.

The following description is provided in both the English and Chinese language:

For myself, I have focused on the online learning environment, in particularly, the IMS Learning Design specification (IMS-LD). The relevant eLearning standards, including SCORM, and also course management systems, e.g., Moodle, have been examined. I have also investigated the global eLearning industry.

I have researched special needs learning theories, in order to provide for the learning styles of learners with autism, and I have examined the teaching approaches to help them to learn. Finally, my research prototypes have been designed and developed based on the IMS-LD, to teach young learners with autism basic mathematics concepts. These prototypes have been evaluated by an expert user group, and I have disseminated my research results in international conferences as well.

在过去两年, 我的研究方向着手于在线学习环境, 尤其是, 教育管理系统(IMS) 学习设计 (LD) 规范. 相应的网络学习标准, 包括 SCORM 和课件管理系统, 例如, Moodle, 也曾经被实验. 同时我也调查了全球网络学习产业.

我研究了特殊需求学习理论, 依此提供给不同的学习例型的自闭症学习者, 而且实验了不同的教育手法来帮助他们学习. 最终, 我设计并开发出一系列基于教育管理系统学习设计规范的研究原型, 去教授儿童自闭症学习者基本的数学概念. 这些原型已经被专家使用团体评估; 我的研究成果也曾被发表在个大国际会议中.

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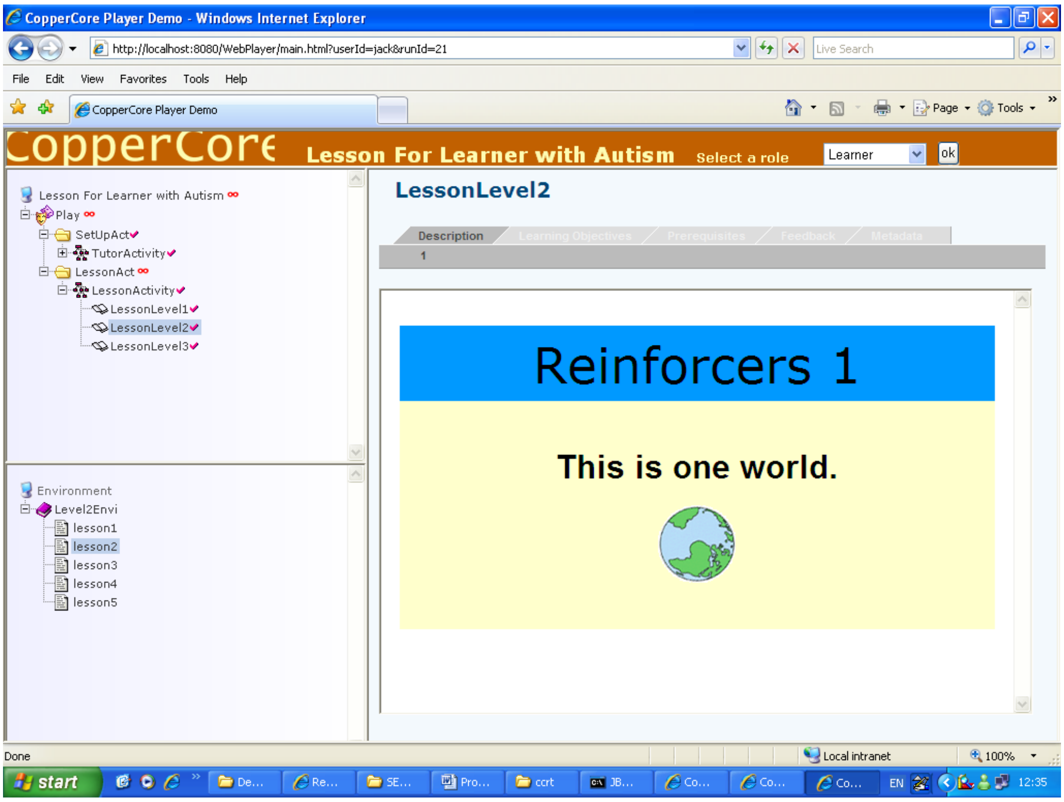
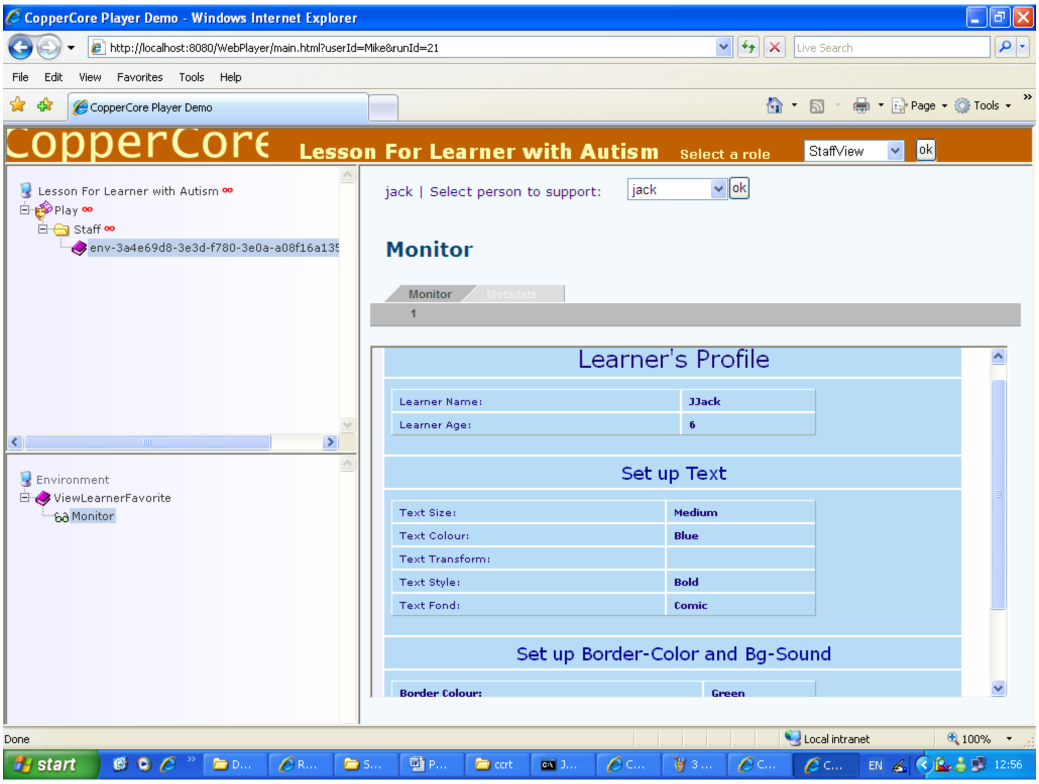
8. Appendices

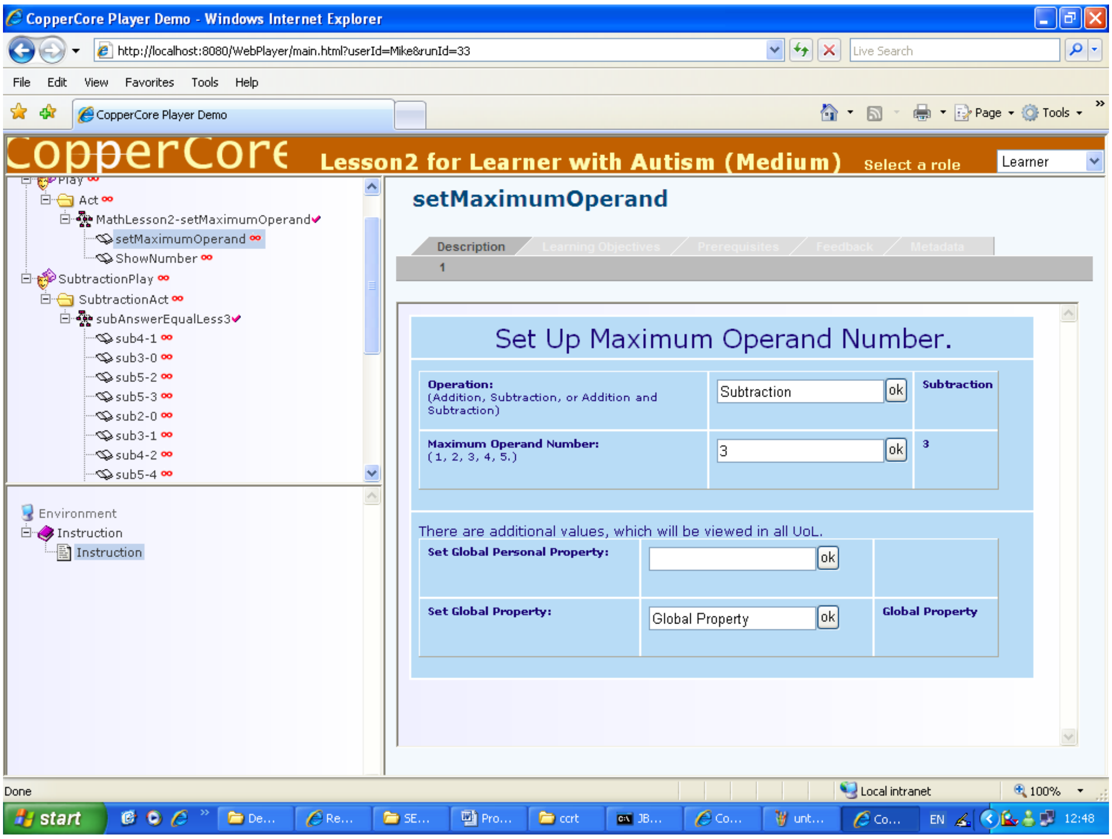
Appendix A: Prototype Screenshots



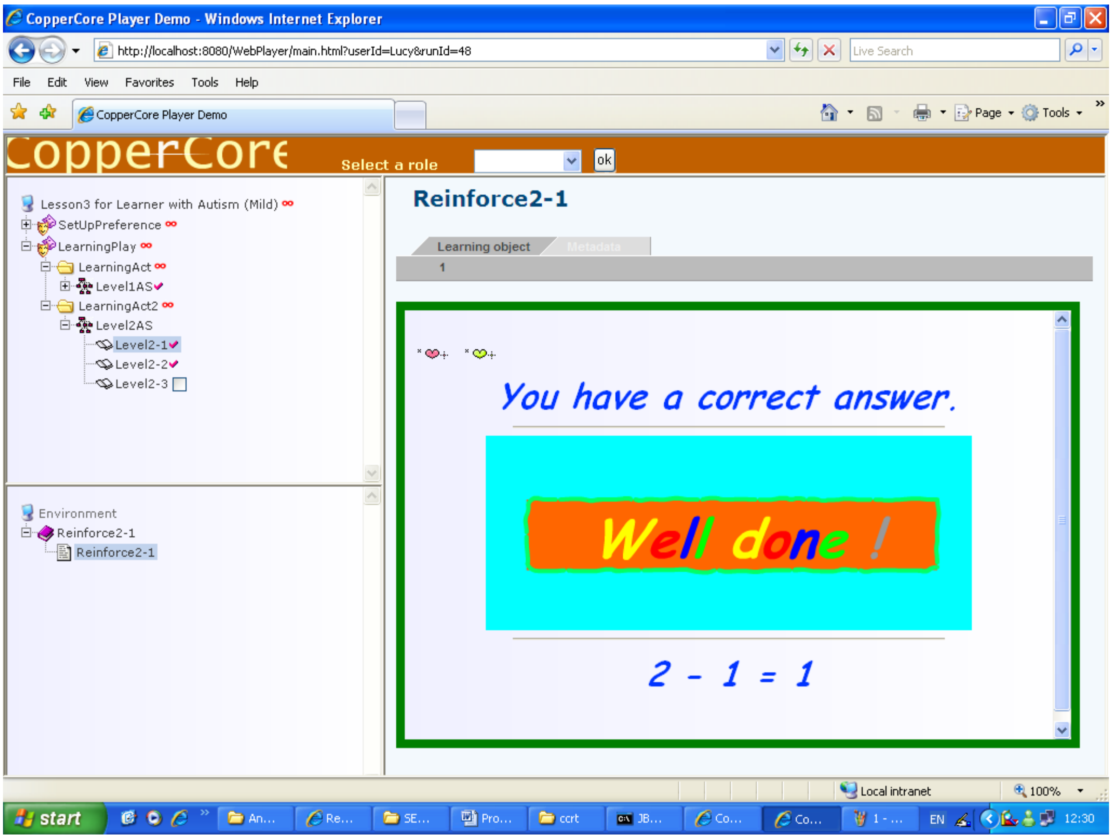
Prototype 1, a Screenshot of the Reinforcer page



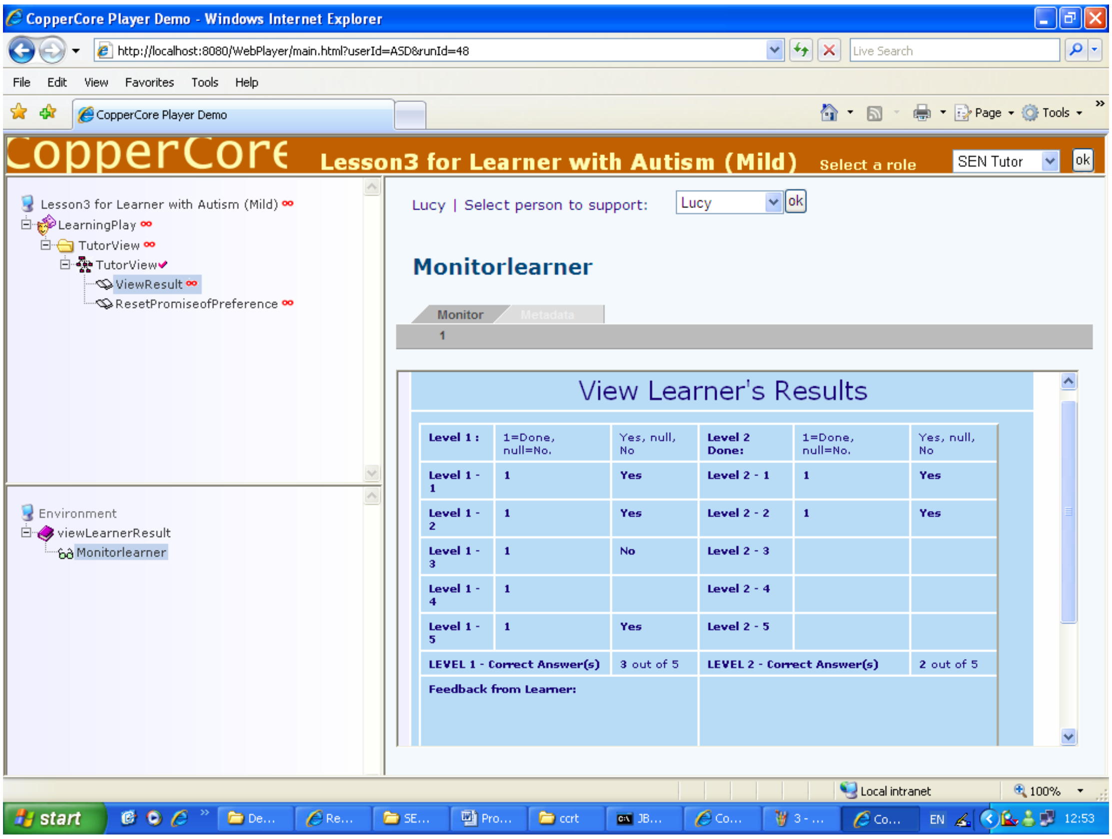
Prototype 1, a Screenshot of the Monitor Service Page



Prototype 2, a Screenshot of the Set up Max Operand Number Page



Prototype 3, a Screenshot of the Lesson Reinforcement



Prototype 3, a Screenshot of the Monitor Learner's Results Page

Appendix B: Evaluation Session Documents

1

Background Information

The prototype lesson was built based on the IMS Learning Design specification (IMS-LD), so that the CopperCore Learning Design Engine software tool will provide a learning interface for learners. The prototype lesson should help learners with autism to learn.

In order to improve the efficiency of the evaluation process, the researcher has set up **one Tutor** and **two Learners** in the learning environment. The evaluation steps (Tasks) are on the next page.

Introduction and Useful Tips

- The system has been configured already to run one prototype lesson for you to evaluate.
- We are interested in getting feedback on this IMS-LD environment, its ease of use and learner support in particular.
- The evaluation tasks will take you through some set-up steps for user preferences.
- Please note the system is case sensitive for now – please input information carefully (e.g. use capital Large, Medium, Small in this prototype).
- You will experience 2 perspectives:
    - As Tutor for special needs
    - Special needs learner

Summary of Evaluation Tasks

First-time user should use sheet 2a, the illustrated version of this task list.

These include tasks in the Prototype lesson evaluation process. Basically, there are two roles in the lesson: one is a SEN (Special Education Needs) tutor and one is a Learner. In the following paragraph, we list the steps of the tasks for evaluators:

As SEN Tutor:

Select a learner, who wants to take the tutorial: (see sheet 2a for illustrated instruction)

Task 1: Select one learner and the lesson of UoL (Unit of Learning). Log in this learner's Run, to set up this learner's details and preferences.

- Learner's profile details. Preference text and background sound.
- Set up the numbers of correct questions to pass the 1st level of lesson.
- Check the example of lesson interface, or modify the preferences, if necessary.

Task 2: Finally, tutor types in ¡°No¡±to hide the 'set up preference' form in preference promise page.

As Learner

Log in the learner's Run:

Task 3: Click the label ¡°lesson 1 - 1¡±in upper navigation bar to start the learning process. The sequences are:

(1). Type the number as answer, and click OK.

(2). Click the check box to finished a lesson, after the word ¡°lesson 1 -1¡±and the check box will change to a tick. The next lesson will appear.

(3). View the reinforcement (Optional), Click down navigation bar, and click ¡°reinforcement lesson 1 -1¡±Then:

- The result for this lesson is shown
- The reward system works

Task 4: Repeat to finish all the 10 lessons, and give feedback text, finally.

As SEN Tutor: The SEN tutor can log into the tutor's Run:

Task 5: Click the navigation bar, to monitor the learner.

Task 6: The tutor can review the feedback.

2a

Evaluation Tasks plus Screenshots

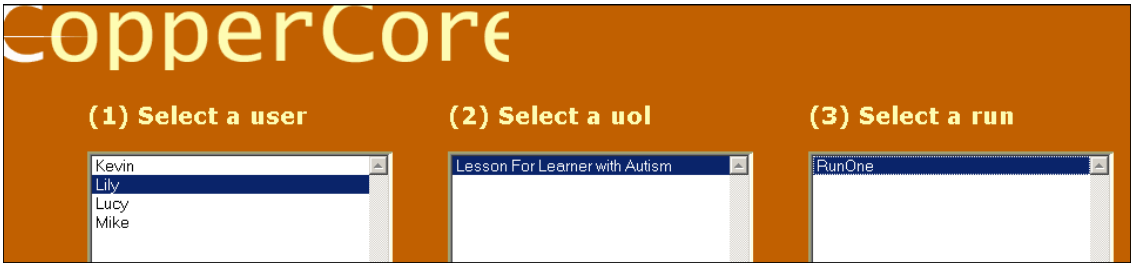
This document merges screenshots in the evaluation steps. It is better to use this version to support the evaluation tasks to be achieved.

As SEN Tutor: Set up the learner's preferences

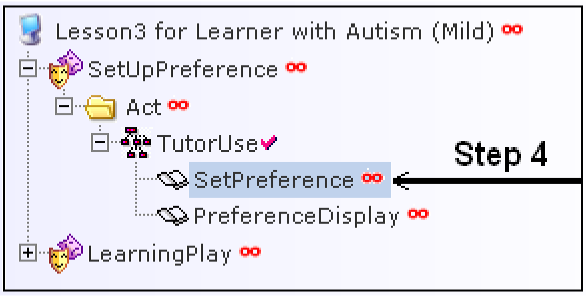
Step 1: Select a learner, who wants to take the lesson, e.g., Lucy or Lily - **single** click on one name.

Step 2: Single click to select the lesson - the UoL (Unit of Learning), e.g., lesson in column 2.

Step 3: Single click to activate this learner's Run. See *Screenshot*, RunOne in column 3.



Step 4: Expand ¡SetUpPreference¡± ¡Act¡± ¡TutorUse¡± then, click the label ¡SetPerference¡±in the upper navigation bar top left, to set up this learner's details and preferences. See example below:



- Learner profile details. Type in the learner's information, **click OK button for every time**.

Learner Name:	Lily	ok	Lily
Learner Age:	7	ok	7
Learner Profile:	Early Learning	ok	Early Learning

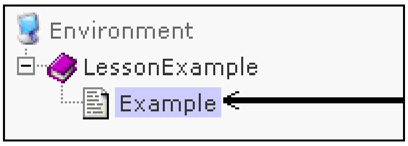
- Set up preferences, e.g., text, background sound. **(Use Capital first letter**, e.g., Medium)

Text Size:	Medium	ok	The Options are: Large, Medium, Small?	Medium
Text Colour:	Green	ok	The Options are: Red, Blue, Green, Yellow, White, Grey.	Green
Text Style:	Bold	ok	The Option are: Bold, Italic, and "Bold+Italic". The default is normal.	Bold
Text Font:	Roman	ok	The Options are: Roman, Comic. The default is Arial.	Roman
Border Colour:	Blue	ok	The Options are: Red, Blue, Green, Yellow, White, Grey. The default is none.	Blue
Back-ground Sound:	false	ok	Choose in true or false The default is none.	false

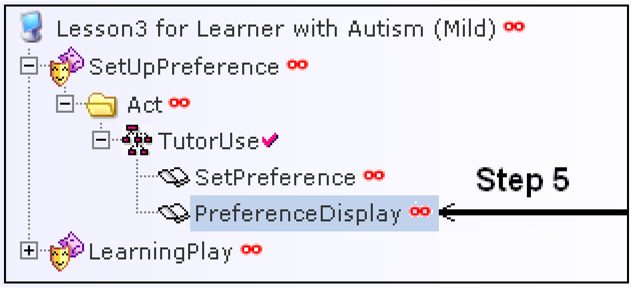
- Set up the numbers of correct questions to pass the 1st level of lesson. (**This step must be set up.**)

Correct answers in lesson part 1	2	ok	Part 1 has 5 questions How many correct answers are needed to allow progress to Part 2.	2

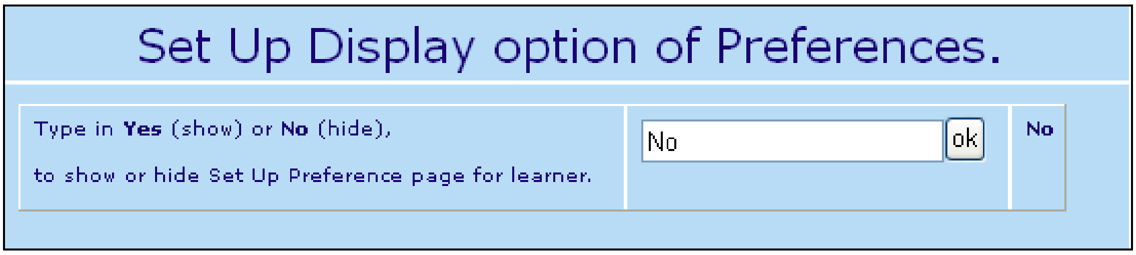
- Expand ¡°LessonExample¡±Click the ¡°Example¡±label in the bottom navigation bar, to view the example of the lesson interface, or redo **Step 4** to modify the preferences, if necessary.



Step 5: Click ¡°PreferenceDisplay¡±label in the upper navigation bar top left, see below:



Then the tutor types in ¡°No¡±and clicks OK button to hide the set-up preferences page.



Step 6: Close this browser window. Click the right corner button to finish setting up the learner's preferences.

As Learner: You now assume the role of a learner to complete the lesson

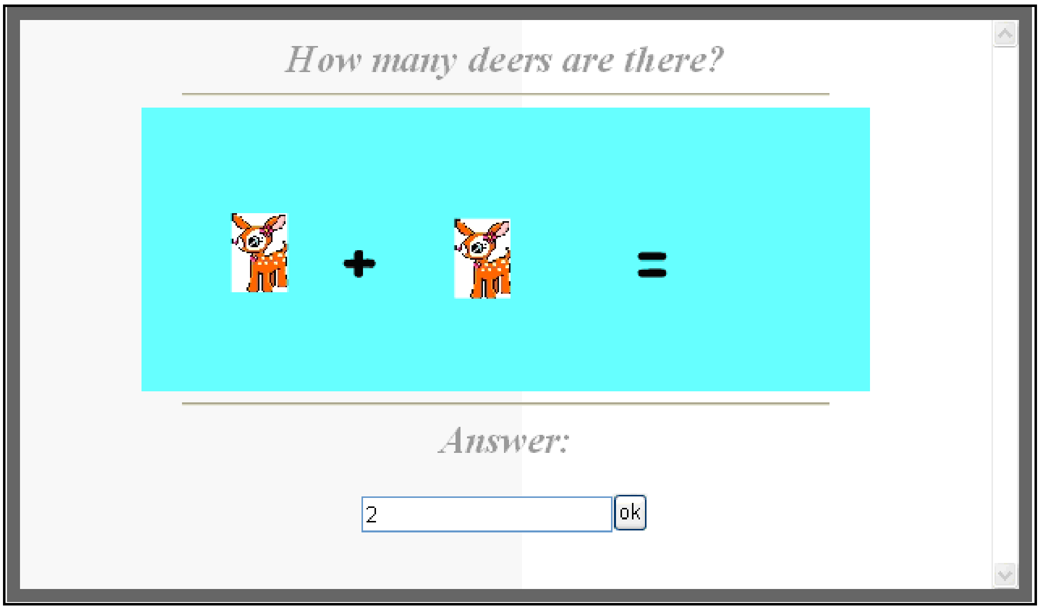
Step 7: Log into the learner's Run (the same way as in with **Step 1, 2,** and **3**), either as Lucy or Lily whichever one you configured earlier.

Step 8: In upper navigation bar top left, expand ⊞ and click the label (the link) ¡°Lesson 1 -1¡±(**Do not tick the Check box yet**)

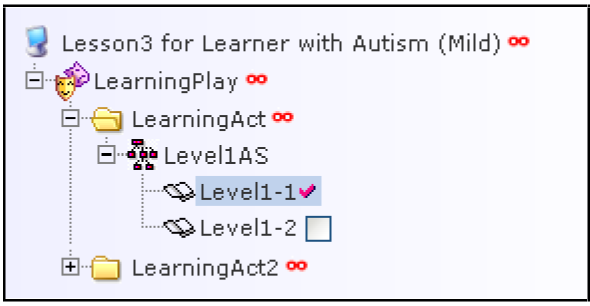
Start the learning process. The sequences are:

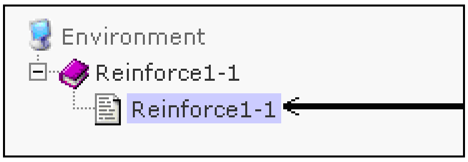
- Observe the lesson content, and type in the number as answer, and click OK.

  Screenshot:

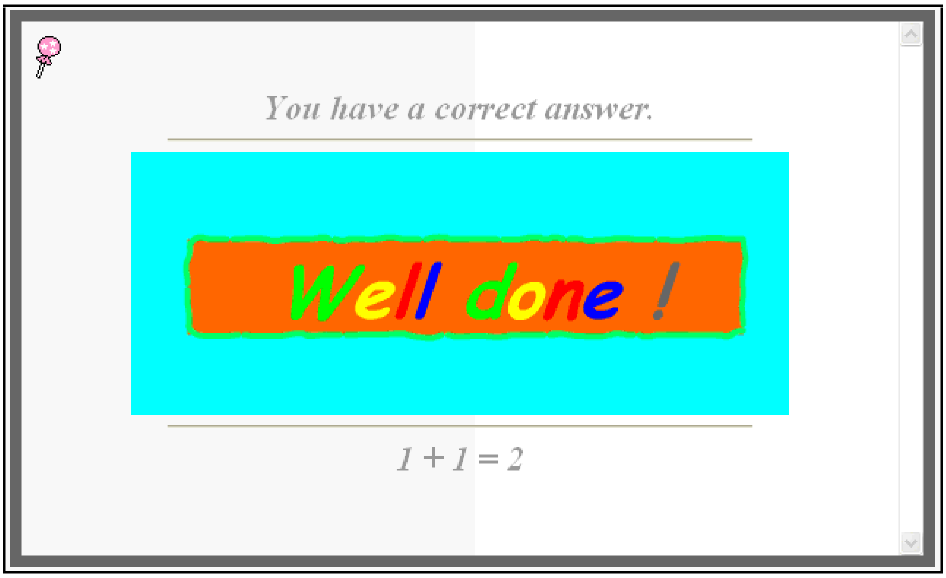


- Click the check box to finished a lesson, which is after the label ¡°Lesson 1 -1¡± and the check box will change to a tick. Then the next lesson will appear, see below:



- View the reinforcement, in the bottom left of the navigation bar, expand ⊞ and click ¡°Reinforce 1 -1¡±label.  Then:

  - The feedback on the lesson is shown – the animation shows the response for the answer.
  - The reward system works – note the ¡°Sweet¡±token in the left corner. (sweets will accumulate for correct answers)



Step 9: Click the label ¡°Level 1 - 2¡±to do the next lesson. Then, repeat **Step 8** (from previous page) to finish all the 10 lessons. (*The lessons 6 to 10 are in second folder ¡°LearningAct2¡±*)

- If the learner does not achieve enough marks (set by SEN tutor in **Step 4,** e.g., more than 2), then the learner can not yet do the second part of the lesson.

Instead of finishing the lesson at the ¡°interspace¡±page, the learner must repeat the first 5 lessons.

Step 10: Then the learner finishes all the lessons. The learner has a text field at the very end to write down his/her feedback for the lesson.

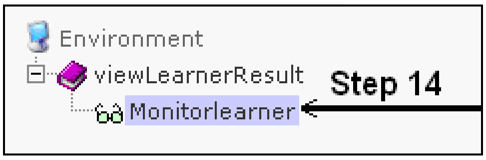
Step 11: Close this browser window. Click the right corner button  to finish learner’s lesson.

As SEN Tutor: Check the result of the lesson, and perhaps reset or change the preferences, if needed.

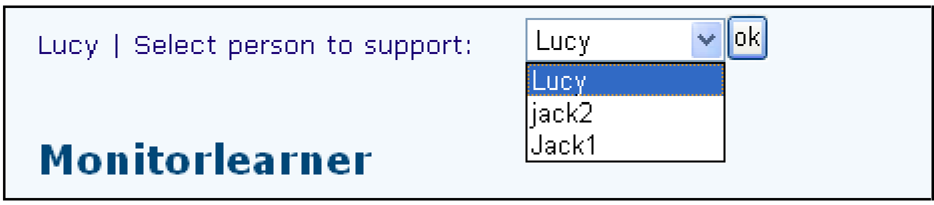
Step 12: The SEN tutor can login tutor's Run (The same steps as **Step 1, 2** and **3**), e.g., Kevin (SEN Tutor).

Step 13: Expand ⊞ and then click ¡ViewResult¡±label in the upper navigation bar, see below:

Step 14: Expand ⊞ and click the ¡Monitorlearner¡±label in the bottom navigation bar.



Step 15: Finally, click the drop down list to select the learner's name, e.g., Lucy, from the drop down list, (Top, Right). Click OK button, see below:



The feedback, learning progress and the result of the lesson are shown.

View Learner's Results

Level 1 :	1=Done, null=No.	Yes, null, No	Level 2 Done:	1=Done, null=No.	Yes, null, No
Level 1 - 1	1	No	Level 2 - 1	1	No
Level 1 - 2	1		Level 2 - 2		
Level 1 - 3	1	Yes	Level 2 - 3		
Level 1 - 4	1	Yes	Level 2 - 4		
Level 1 - 5	1	Yes	Level 2 - 5		
LEVEL 1 - Correct Answer(s)		3 out of 5	LEVEL 2 - Correct Answer(s)		out of 5
Feedback from Learner:					

(At this point the tutor has the option to reset learner preferences if needed)

Step 16: Close this browser window. Click the right corner button to finish the entire lesson.

Questionnaire

Please take a few minutes to answer the following questions. Please tick one box in each row to record your level of agreement with each statement.

Categories	Comment	Levels of agreement				
		Strongly Agree 5	Agree 4	Neutral 3	Disagree 2	Strongly Disagree 1
Configuration	1. The IMS Lesson environment is easy to configure.	?	?	?	?	?
Operability	2. The IMS-LD based prototype operates well at run-time.	?	?	?	?	?
Easy of use	3. This prototype lesson is easy to use.	?	?	?	?	?
Multimedia	4. The multimedia helps the learner to understand the lesson.	?	?	?	?	?
Personalisation	5. The level of personalisation (Individual Preferences) is satisfactory.	?	?	?	?	?
Dynamic aspects	6. The learning flow to complete the learning task is well structured.	?	?	?	?	?
Suitability	7. The lesson provides appropriate feedback on error.	?	?	?	?	?
Attractiveness	8. The prototype lesson interface is attractive for learners.	?	?	?	?	?
Understand-ability	9. The learner can understand the learning content in the lesson.	?	?	?	?	?
Learning potential	10. Learners could learn from this IMS-based mathematics lesson.	?	?	?	?	?

Thank you for the time taken on this evaluation exercise.

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Additional comments

1. Please give some comments on the personalisation facility in the IMS-LD environment.

2. Could you please provide a comment on any drawbacks that are evident in the use of the IMS-LD environment. (Continue overleaf if necessary)

Appendix C: Statistical Tables

Question 1: Ease of Configuration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	1	12.5	12.5	12.5
	(b) Agree	4	50.0	50.0	62.5
	(c) Neutral	1	12.5	12.5	75.0
	(d) Disagree	2	25.0	25.0	100.0
	Total	8	100.0	100.0	

Question 2: Operability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	2	25.0	25.0	25.0
	(b) Agree	6	75.0	75.0	100.0
	Total	8	100.0	100.0	

Question 3: Easy of Use

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	1	12.5	12.5	12.5
	(b) Agree	4	50.0	50.0	62.5
	(c) Neutral	2	25.0	25.0	87.5
	(d) Disagree	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Question 4: Multimedia

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	3	37.5	37.5	37.5
	(b) Agree	5	62.5	62.5	100.0
	Total	8	100.0	100.0	

Question 5: Personalisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	3	37.5	37.5	37.5
	(b) Agree	4	50.0	50.0	87.5
	(c) Neutral	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Question 6: Dynamic Aspects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	4	50.0	50.0	50.0
	(b) Agree	1	12.5	12.5	62.5
	(c) Neutral	3	37.5	37.5	100.0
	Total	8	100.0	100.0	

Question 7: Suitability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	3	37.5	37.5	37.5
	(b) Agree	2	25.0	25.0	62.5
	(c) Neutral	1	12.5	12.5	75.0
	(d) Disagree	1	12.5	12.5	87.5
	(e) Strongly Disagree	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Question 8: Attractiveness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	4	50.0	50.0	50.0
	(b) Agree	3	37.5	37.5	87.5
	(c) Neutral	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Question 9: Understandability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	4	50.0	50.0	50.0
	(b) Agree	3	37.5	37.5	87.5
	(c) Neutral	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Question 10: Learning Potential

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	(a) Strongly Agree	5	62.5	62.5	62.5
	(b) Agree	3	37.5	37.5	100.0
	Total	8	100.0	100.0	

Appendix D: Recent Compatibility Experiments

An IMS content package in Moodle (v. 1.9), displayed correctly

An IMS Learning Design (Level B) UoL in Moodle (v. 1.9), not displayed correctly

Appendix E: Publications

E-Learning in Special Education: Applying the IMS Learning Design Specification

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Abstract:
The IMS Learning Design Specification (IMS-LD) is investigated in this research, to provide advantages including a more dynamic and adaptive e-course than traditional online pedagogical strategy, for learners with special needs. It is a new standard for e-learning development that can be explored for a variety of learner needs. This specification has three levels: Level A, B and C. These levels provide different features to support learning scenarios to suit users' profiles. This project examines the appropriateness of the IMS-LD in Special Education. IMS-LD Level B in particular may be appropriate for configuring the learning material to suit special needs. We investigate the tools needed for e-learning, including the description of learning content and learning activities in the appropriate run-time environment.

Reference:

Yu, G. and Barry, M. (2007) E-Learning in Special Education: Applying the IMS Learning Design Specification. In C. Montgomerie & J. Seale (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007 (pp. 3843-3847). Chesapeake, VA: AACE.

Features in the IMS Learning Design Specification to Support Special Needs Learning

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Abstract:

This paper focuses on the IMS Learning Design Specification in order to examine a new pedagogical context in special education software development. It aims to investigate and explore instructional features of the IMS Learning Design Specification Level B, namely the Property and Condition features. We also investigate their integration with other web technologies in order to address the needs of learners with autism. Three prototype lessons have been implemented to examine the IMS Learning Design Specification Level B features. The lesson development phases have allowed for experimenting with these features, which show promise in terms of the development of personalised learning for special needs.

Reference:

Yu, G. & Barry, M. (2008) Features in the IMS Learning Design Specification to Support Special Needs Learning. In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2008 (pp. 5523-5528). Chesapeake, VA: AACE.