Enhancing Student Learning Journeys with Semantically Annotated Content

A thesis submitted towards the degree of

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By

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ABSTRACT

There is an increasing interest in developing existing Special Educational Needs (SEN) teaching methods due to recent concerns regarding the number of SEN pupils in schools. Communication is difficult for students when they have little or no clear speech. Consequently, a range of communication systems are used as an alternative to speech, including symbols, pictures or gestures. Importantly, helping students to better communicate also improves their education, friendships and independence. However, it is acknowledged that creating these educational resources is time consuming and expensive, and the learning results are not recognised as being as effective as required. Semantic Web technology has had an impact in the educational field and offers the required linkages for more engagement with Web content. There is, however, a considerable gap in Semantic Web research between the contributions in the mainstream educational field and research undertaken into special educational needs (SEN) students.

This thesis presents an augmented World Wide Web (WWW) vision utilising annotation to more effectively support diverse special educational needs students. Students are supported in part by a SEN Teaching Platform (SENTP), one artefact from this design science research. Poetry is used as a website teaching material because of its significant impact on special needs students as it is a difficult topic to understand. The first stage of the research is to select the appropriate tools for testing annotation techniques in a real SEN environment. Later, a design of the proposed SEN teaching platform is built based on a Semantic Web annotation tool (Amaya) coordinated with a web application. Design is evaluated by conducting a pilot study in schools caring for special needs students (SEN). Evaluations were carried out at two schools, interviewing nine participants (Teachers, Teaching Assistant) in the UK. SENTP is tested for using Semantic Web technology to benefit the education of SEN students by utilizing Semantic Web annotation tools. This research further improves the SENTP with additional support for cognitive load using specific annotation formats within the Amaya annotation tool. Field testing is carried out at six UK schools with twenty-two participants being interviewed. Cognitive load principles are shown to improve both learning and class behaviour, also supporting teachers in the production of educational

content. The pilot study and field testing results reveal that the proposed approach is effective. Following this, designed artefacts are synthesised within a wider design blueprint that articulates how this new world of annotated digital media is designed, deployed and consumed. Finally, SENTP ontology is created using OWL language and Protégé 5. The main goal of this ontology is to produce a wider design SENTP ontology that can be adapted to wider teaching purposes.

DEDICATIONS

This thesis is dedicated to my children

Wafa, Aiat, Noor and Hussain Leelo

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PUBLICATIONS

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ABBREVIATIONS

ADD/ADHD: Attention Deficit Hyperactivity Disorder

AI: Artificial Intelligence

ASD: Autism Spectrum Disorder

ASP: Asperger's Syndrome

AUT: Autism

CLT: Cognitive Load Theory

CL: Cognitive Load

CP: Cerebral Palsy

DAML: DARPA Agent Markup Language

DCD: Dyspraxia

DDI: Universal Description, Discovery, and Integration

DOWN: Down Syndrome

DSR: Design Science Research

DYC: Dyscalculia

DYL: Dyslexia/SpLD

DfE: Department for Education

HTML: Hyper Text Markup Language

IARE: Institute for the Advancement of Research in Education

IS: Information Systems

MILD: Mild Learning Difficulties

MLD: Moderate Learning Difficulties

MSI: Multi-sensory Impairment

OWL: OWL Web Ontology Language

OWL-DL: OWL Description Logics

OWL-full: Version of OWL

OWL-Lite: Version of OWL

OWL-S: Web Ontology Language for Web Services

PECS: Picture Communication Symbol

PMLD: Profound and Multiple Learning Difficulties

RDF: Resource Description Framework

SAWSDL: Semantic Annotation for Web Service Description Language

SDM: SEN Development Media

SEN: Special Educational Need

SLD: Severe Learning Difficulties

SLD: Speech and Language Difficulties

SOAP: Simple Object Access Protocol

SENTP: SEN Teaching Platform

SW: Semantic Web

SWS: Semantic Web Services

URI: Uniform Resource Identifier

VOCA: Voice-Output Communication Aids

W3C: World Wide Web Consortium

WM: Working Memory

WWW: World Wide Web

XML: Extensible Markup Language

DTD: Document Type Definition

UI: User Interface

CRB: Criminal Records Bureau

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Chapter 1: Introduction and Motivation

'Every child is unique – in characteristics, interests, abilities and needs; and every child has the ability to enjoy his or her rights without discrimination of any kind.' (Thomas Hammarberg, 1997)

1.1 Background and Motivation

This chapter provides an overview of the background and motivation of the current research, starting with the rationale and boundaries of the research. Then, the significance of the research and primary objectives are explained. The chapter concludes with an overview of the structure of this thesis.

Special educational needs cannot be regarded as a marginal issue, as 985,000 people in England have a learning disability (2% of the population) (English Federation of Disability Sport, 2010). Of this number, 770,000 are aged under 16 (6% of the child population) (Papworth Trust Disability Facts and Figures, 2010). There are 55,000–75,000 children with a moderate or severe learning disability in England (Department of Health, 2007). The students with SEN often have limited vocabulary, unlike other children of the same age, who typically have a dictionary-based vocabulary in their heads without knowing all the words. Words do not always make sense literally, such as the phrase 'Can you lend me a hand'? For those with SEN, understanding words can be a challenge if they are imaginative, figurative or emotional words (Zane Education, 2015). Thus, teachers mainly use visual resources, such as graphic symbols, sign language, or images (Abbott and Lucey, 2005). However, special needs schools still heavily rely on manual methods. The use of signing, photos, symbols and objects assist people to develop their speech and vocabulary (Department of Education, 2006). The main symbol sets used by students in the UK are Widgit, Makaton, Picture Communication System (PECS), and Blissymbols. In addition, computers are often used such as the utilisation of the internet or the Microsoft Office application. These methods are expensive, difficult for teachers to create and use, and difficult to utilise to teach the whole class without one-to-one support for individuals to accomplish their learning goals (Millar, 2010). Furthermore, teaching staff always face significant challenges in controlling students' behaviour as students often have different special needs issues (Hays et al., 2010). Reading for understanding is especially challenging for individuals with Autism Spectrum Disorders (ASDs) (Randi et al., 2010).

Poetry is acknowledged as one of the most challenging topics to understand, particularly for autistic children as they struggle to understand the underlying meaning of the poetry. However, poetry is seen as an interesting and fun topic for children with a full range of SEN, and is a vital part the English curriculum. The benefits of computer technology for children with SEN has been established in several studies over the past two decades (Khan, 2010; Doyle and Sanchez, 2011; Tan and Cheung, 2008; Gross and Voegeli, 2007; Alty et al., 2006). However, all types of learning disabilities, which affect nearly 20% of internet users, could be better supported by making the web content more accessible and efficient (Liu, Cornish and Clegg, 2007; WebAIM, 2017). The Web has been used in education for a long time in adaptive learning, e-learning, and distance learning. The evolution of the internet is termed the 'Semantic Web', which is provided by the World Wide Web Consortium (W3C) (Allemang and Hendler, 2011). The Semantic Web is an extension of the current traditional World Wide Web (WWW) that enables people to share content outside the applications and website limits, adding semantic description and ontologies (Berners-Lee, 1989; Semantic Web, 2012). One benefit is that such description and modelling helps to provide additional meaning to the information on the Web, making machine content understandable (McIlraith et al., 2001). In recent years, the Semantic Web has been applied to the educational field, to retrieve relevant material and add semantic annotation to documents. One such technology, the semantic annotation tool, is starting to gain traction, with automatic annotation tools such as Magpie, semi-automatic such as OntoMat-Annotizer or more manual approaches such as Amaya (Dawod and Bell, 2011). However, from the existing literature, there is no research evidence of any work conducted in relation to the use of semantic annotation to support SEN teaching, which is perceived as a research gap for this study. This chapter sets the scene of the research by outlining the methodology for discovering the use of a semantic annotation tool in SEN education and specifically in teaching poetry. Consequently, this work is intended to propose an actionable design process for annotated SEN media creation – operationalised as a blueprint to enhance the learning of SEN students.

1.2 Research Aim and Objectives

The aim of this research is to investigate how adaptive special needs educational systems can benefit from Semantic annotation techniques to enhance teaching and learning methods and support the teaching staff with their routine work. Subsequently, the aim of this research is to propose a novel method (blueprint) for the application of semantic annotation within a SEN teaching journey. In fulfilling this aim, the following objectives are considered important:

1. Review the available SEN teaching resources to provide an understanding of the state-of-art of special needs learning resources and to identify the limitations of the current teaching methods.
2. To conduct a comprehensive literature review in a Semantic Web innovation with a focus on adapting semantic annotation in education with the aim of identifying the associated gaps in using semantic annotation in teaching SEN students.
3. To develop an ontology seeking to identify the main design constructs along with their semantics and relationships that are needed to be examined with SEN teaching material.
4. To develop a conceptual framework of the SEN learning model concept that identifies and links between the main components of the concept (semantic annotation) along with its modelling principles, practical functions within schools for SEN students, and its relationships with other relevant concepts such as the learning methods and styles, issues and the teaching staff requirements
5. To develop and implement a tool that facilitates the framework by employing semantic annotation techniques in SEN learning materials

6. To evaluate and demonstrate the practical adequacy of utilising semantic annotation techniques in SEN students' education using suitable evaluation methods.
7. To design a Blueprint to synthesise a policy recommendation describing the interaction between students and activity designer to generalise the process of creating media element within SEN environment.
8. To draw conclusions from the building and evaluating the use of semantic annotation in developing special needs resources to enhance SEN learning. Also, identify future research directions that are important to continue refining and developing this significant area of research.

1.3 Research Methodology

This research follows a design science research (DSR) approach through which learning of the problem space is accomplished through artefact evolvement and evaluation (March and Smith, 1995; Peffers et al., 2007; Vaishnavi and Kuechler, 2007). DSR is a problem-solving research paradigm, which is aimed at designing innovative and effective artefacts as a solution to research problems (Hevner et al., 2004). DSR is considered appropriate for this project since the aim of this research is to design an effective and easy to use solution for the crucial problem of adapting semantic annotation in SEN learning process. A design vision was formulated from literature and a feasibility study undertaken that included identifying requirements.

The process incorporates a set of design and behavioural science activities; build, evaluate, justify and theorise (March and Smith, 1995). Across these activities, the desired design artefact is developed, deployed and tested using suitable evaluation methods and metrics. The DSR process can be iterative, and the 'build, evaluate, justify' process can be repeated until satisfactory artefacts are obtained (Markus et al., 2002). The DSR process of this project is an iterative one; the proposed semantic annotation of the SEN teaching approach is developed and tested in each stage without full specifications or requirements from the users. Instead, development starts with basic specifications and requirements for all software used and tested in the school environment. After an empirical testing in real SEN domain, the initial requirements are reviewed and any further requirements are identified. The process is then repeated, producing a new version of the application for each cycle of the model. In addition, in the iterative model, the product is built and improved step by step; hence, defects can be tracked in the early stages. This avoids the downward flow of defects, specifically when tested in schools that cater for SEN students who are accustomed to a specific programme and routine. The DSR cycle provided by Kuechler and Vaishnavi (2008a) and presented in Figure 3.3 is utilised in this research.

This cycle is composed of five phases, called awareness of problem, suggestion, development, evaluation and conclusion. Hence, the role of design artefacts is suggested as central in any DSR project. Artefacts represent solutions to the defined research problems (Orlikowski and Iacono, 2001). March and Smith (1995) classify DSR artefacts into constructs, models, methods, instantiations and arguably design/utility theories. The final artefact of this research is an 'instantiation', which is evaluated for its practical adequacy through practical tests at schools catering for SEN students. The evaluation of its practical adequacy is achieved by looking into its application on three main factors that affect the education of SEN students: (1) students' understanding; (2) students' behaviour; and (3) lesson preparation time. The reasons behind choosing these three factors are that: (a) They cover various aspects of SEN students' needs for an effective lesson; and (b) they are three different types of factors, which demonstrate the practical adequacy of using semantic annotation in various SEN contexts. The annotation tools in each stage are evaluated according to a set of criteria, which is evaluated for completeness, simplicity, ease of use, fidelity with real-world phenomena, consistency, robustness, efficiency, effectiveness, generality, and level of detail, validity and elegance. These factors are based on March and Smith's research (1995).

The evaluation in this thesis is based on the literature and feedback from interviewing teaching staff. The main design research phases are as follows:

Problem Awareness: This involves a comprehensive review on the literature to analyse the effectiveness of the current special needs teaching methods and to evaluate current semantic annotation techniques. In addition, review the literature to analyse the lack of utilising semantic annotation tools in SEN educational domain.

Suggestion: This phase involves introducing a provisional idea of how the problem might be solved by the design of an appropriate framework. This step originates in Iteration 1 with the development of an appropriate concept SEN Teaching Platform (SENTP) framework. Further suggestions arise in later iterations; For example, testing the framework in real SEN domain, when interviewing teaching staff is used to analyse how the use of semantic annotation have impact on teaching SEN students. As new knowledge is gained during development and evaluation of the developed framework, new suggestions from the build and evaluate cycles are used to initiate subsequent iterations.

Development: Tentative Design is further developed and implemented in this phase. The development of the solution is achieved by building a research artefact. The artefact is SEN Development Media (SDM) framework. At each stage, the researcher obtains an understanding of the problem space by immersing themselves in the building activity to understand the problem, raising new suggestions to improve the next build-and-evaluate cycle. Finally, designed artefacts are synthesised within a wider design blueprint that articulates how this new world of annotated digital media is designed, deployed and consumed.

Evaluation: This phase is concerned with the development of an assessment method to assess the quality and effectiveness of the designed artefact (March and Smith, 1995)**.** Synthesising the Design Research evaluation criteria to identify appropriate evaluation methods from the problem space has lead to identifying the SENTP blueprint and ontology. The SENTP is evaluated in three stages to test its effectiveness and efficiency. In the first iteration, the SENTP is evaluated according to a set of criteria based on the literature review. In both the second and third iteration, the SENTP is evaluated according to interview feedback and the generated set of user requirements. The second iteration user requirements are based on the feedback from the first iteration, while the third iteration is based on the feedback of the second iteration and the cognitive load theory principles as well as its impact on SEN students.

The final phase of the design research cycle presents an understanding of how and why the solution works in the problem domain when applied to a real SEN educational field.

Conclusion: This is the final phase of the design sience research cycle, ascertained from the learning that emerged from understanding how and why the solution works in the problem domain when applied to a real SEN environment. Limitations of the solution and areas for future work are also provided in the conclusion of the research. Applying March and Smith's (1995) Design Science Research product classification to illustrate research contributions leads to identifying the main design artefacts. The activities in this research are executed in an iterative DSR method, consisting of following three design iterations:

Iteration 1 (Construct and Model: Select Annotation Tool): A comprehensive SENTP framework is developed by synthesising and analysing the literature review and experimenting with Semantic Web techniques. The framework includes SEN Ontology, SEN Educational Website and the use of annotation tools to build SEN Educational Semantic Web. This iteration provides new way of describing special need language. Primarly, explaining how and why constructs work by employing them to describe poetry teaching material. It explains why and how a semantic annotation process (method) adapted in teaching SEN students based on literature and application experiment. Empirical evidence has been found from developing and implementing two instantiations to understand how and why the application works within the SEN domain. As a result of this, one semantic annotation adopted for testing in real environment.

Iteration 2 (Build Annotation Tool): Extending the framework to incorporate the symbol taxonomy (model). Adopt new way of describing the language using the most commonly used communication languages in UK within school age range (construct). The symbol systems are one of the main effective ways used to teach special needs, in addition to images. They are Makaton, Widgit, and Picture Communication System (PECS) (method). SENTP demonstrated in pilot study across different SEN domains to understand how and why application works within SEN domain (Instantiation).

Empiracial evidence has been found from the initial interviews with teaching staff (teachers, teaching assistants) supporting the literature review. As a result of this, the adoption of the symbol systems in addition to images, sound and text with semantic annotation addressing better teaching and learning (understanding, engagement and behaviour problems). Moreover, the class was better managed by the teaching staff (preparation). Therefore, the importance of conducting empirical research throughout the next iterations is clear, whilst utilising and building on the initial framework.

Iteration 3 (Field Testing Annotation, create SENTP blueprint and ontology): Validate and extend the framework by applying and evaluating the semantic annotation method across other SEN domains. Also, Cognitive load theory employed with the semantic annotation process using in developing the SENTP user interface (method). An Instantiation is created and demonstrated in a field testing annotation study to real case scenarios to understand how and why the application works within different SEN domains. As a result of this, the adoption of cognitive load theory is shown to improve both learning and class behaviour, also supporting teachers in the production of educational content. Further interviews with teaching staff show that they are facing problems of preparing resources and manage the class behaviour, in addition to other concerns mentioned in chapter 6. Therefore, it proves that semantic annotation has a significant impact on special need students, in particular autistic. Interestingly, younger students, whose English as an additional language, not considered SEN students, also benefited from the approach.

The generality of this work is demonstrated by proposing a novel method (blueprint) for the application of semantic annotation within a SEN teaching journey in this iteration. In addition, SENTP ontology is created using OWL language and Protégé 5 (model). This ontology shares the understanding of SEN learning domain and the related information among activity designers. Moreover, the ontology concept method is needed to assist users to retrieve the documents that are most related to the user's query.

1.4 Thesis Overview

In achieving the objectives of the work, the thesis is structured as follows:

Chapter 2: Drawing extensively from the literature, this chapter presents a review of relevant research articles, giving a general background of four intersecting fields of research relevant to this study. Firstly, a comprehensive overview of different types of special needs issues and their associated styles of learning is introduced, leading to identify the teaching methods suitable for each case. Secondly, the chapter proceeds by discussing the existing teaching methods to identify the teaching requirements. Thirdly, a background discussion of employing ICT Technologies in teaching is presented according to their relevance towards special educational needs. Finally, a broad overview of the required technologies for the Semantic Web technology is presented. Furthermore, it will introduce benefits and drawbacks of using Semantic Web techniques in education, in particular, the use of semantic annotation in teaching. The aim of this literature review is to gain an understanding of the state-of-the-art in the above domains and learn further about the ways in which semantic annotation may enhance the teaching process of special needs and support the teaching staff with their routine work.

Chapter 3: This chapter proposes design science research (DSR) as the research methodology for effectively conducting valid Information Systems research. It then discusses how this methodology is applied in order to plan and execute the research design problem, by developing a method for utilising semantic annotation process in teaching special need students. Furthermore, to design blueprint that articulates how the results from the artefacts are synthesised.

Research iterations are identified and research outputs are categorized according to the design science research products classification. Five DSR phases are identified, which are: (1) awareness of the problem; (2) suggestion; (3) development; (4) evaluation, and; (5) conclusions. The chapter discusses issues relating semantic annotation process, building ontologies and models throughout the research steps. The chapter critically studies and analyses the assessments of DSR artefacts to provide suitable methodological evaluation for the developed framework. Finally, the chapter is summarized.

Chapter 4: This chapter presents the first design science research iteration, tackling the first task of selecting the appropriate tools for this research. The steps comprise an experimental process by testing different annotation tools. Then, understanding and analysing the existing knowledge base (literature review) to understand the background use of different annotation techniques in teaching to select the suitable tools to be used in school care for SEN students with range of issues and age. The output of this iteration is presented as a set of design science research products.

Two SEN teaching platforms (SENTP) model designed and implemented for the purpose of comparing and selecting the most appropriate annotation tool for application within the SEN domain. The design of the selected approaches is based on a set of design criteria derived from the literature. Therefore, the empirical work in this chapter lays down the necessary groundwork for the SEN Teaching Platform (SENTP) that is subsequently evaluated with research outputs.

Chapter 5: This chapter refines and extends the outcomes of the first iteration of the research by developing the initial framework developed in chapter 4. The extention of the framework includes adding new way of describing the special needs language such as symbols (Makaton, Widgit and PECS). This chapter presents the implementation of the second Design Research iteration by incorporating the symbols as part of the metadata used to design the SENTP. Also, based on the feedback from chapter 4, metadata that is approved to cause disturbing in the class deleted. This chapter also discusses the pilot study process at two schools; the potential problems associated with the selected annotation techniques, and provides a set of guidelines for overcoming such problems. The results of the pilot study conducted using a reliable data analysis computer package. The output of the pilot study is evaluated at different environment of real SEN domain.

Chapter 6: The third research iteration is executed here to improve and validate the generality of the framework, by applying the framework to different sets of SEN students within a wider SEN domain. The framework in this chapter is extended by adding additional support for cognitive load using specific annotation formats within the selected annotation tool. Details of the SENTP structure, design and then practically how this SENTP is implemented and presented for literacy lessons in school. Furthermore, an evaluation of the SENTP is presented after use in the classroom. The demonstration of SENTP tests the effect of semantic annotation techniques on reducing the students' cognitive load in order to use the working memory more efficiently to improve student understanding. Evaluation of the developed SENTP is done by analysing and examining data from six schools that cares for special need students.

Finally, designed artefacts are synthesised within a wider design blueprint that articulates how this new world of annotated digital media is design, deployed and consumed. SENTP ontology is created to produce the desired teaching ontology for learning any teaching material for special need student with issue range. The chapter concludes by providing a summary of the research findings using design blueprints to surface earlier findings where annotated content is used within a number of schools and the SENTP architecture is being constructed in response.

Chapter 7: This chapter concludes the research thesis and presents the contributions and key findings. An evaluation of the design research process is performed against satisfying the research aim and objectives, highlighting the research limitations. Final output of design science research artefacts is presented which represent overall findings from the three iterations in chapter 4, 5 and 6. Finally, relevant conclusions will be drawn on the degree to which the proposed approach meets its objectives, while further studies in the research area based on the research limitations are presented.

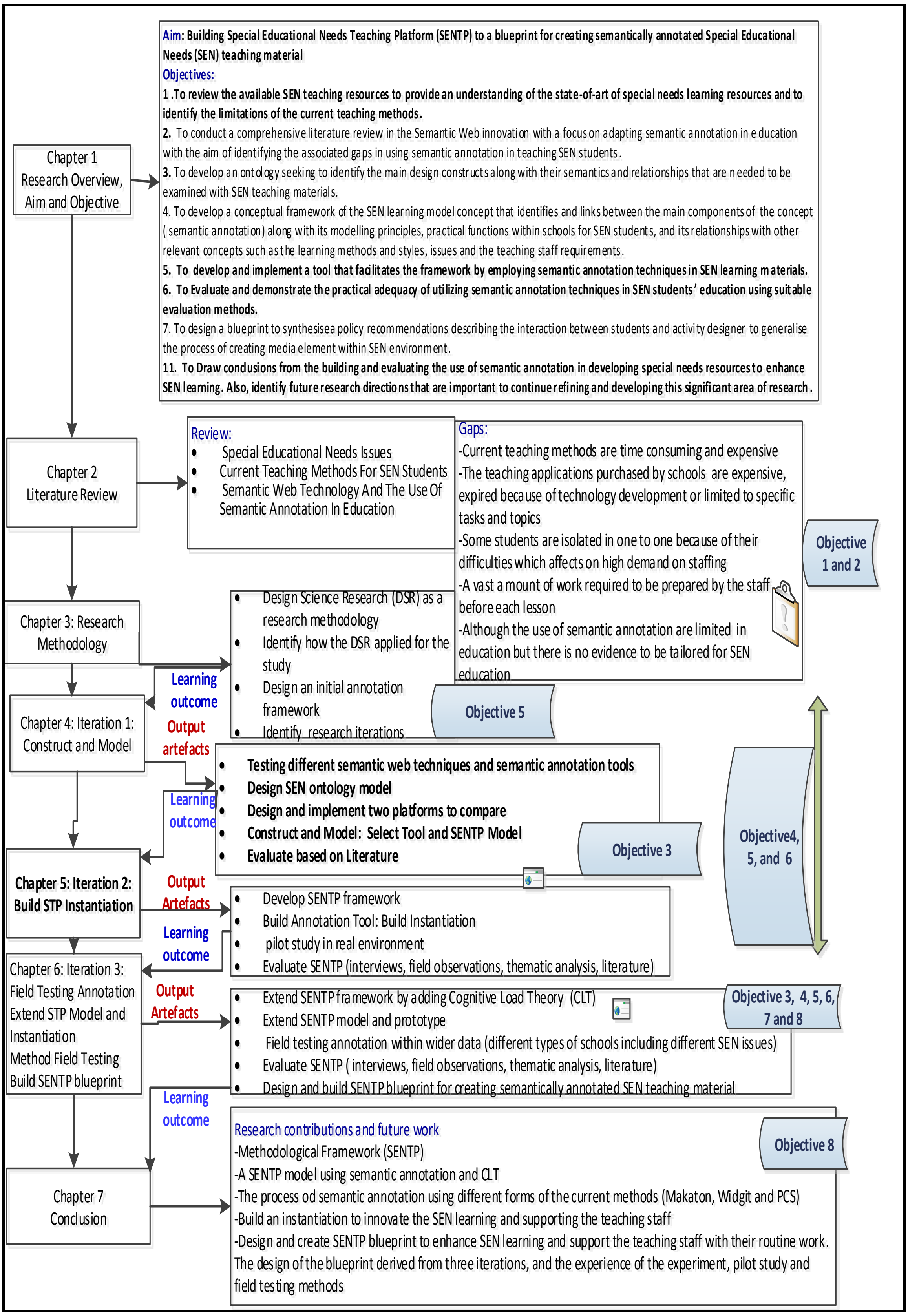


Figure 1.1: Thesis Outline

Chapter 2: Literature Review

2.1 Introduction

The literature review of this chapter exposes the limitations associated with the current methods employed in teaching SEN students and the use of semantic annotation in such teaching. This chapter critically reviews four intersecting fields of study that are necessary for this research: SEN issues, current teaching methods, facilitation of teaching SEN students with ICT technology and the use of semantic annotation in teaching.

The aim of this literature review is to: (1) investigate various SEN student issues, with the state-of-the-art approaches to their learning styles; (2) discuss the limitations associated with the current teaching methods used in teaching SEN students; (3) discuss the challenges relating to class management and resource preparation; (4) provide an understanding of the state-of-the-art approaches in existing research relating to the use of semantic annotation in teaching. This literature review aids in identifying the research gaps in the use of semantic annotation as a tool to aid the teaching process of SEN students. The literature review also facilitates the selection of a suitable research methodology for addressing the identified gaps.

This chapter is organised as follows: Section 2.2 briefly reviews various special educational needs (SEN) issues, Section 2.3 provides a comprehensive review of the current state-of-the-art in SEN teaching and exposes the limitations of the existing methods and the current challenges associated with teaching SEN students. Section 2.4 briefly reviews various aspects of Semantic Web Technology and Section 2.5 presents a broad overview of semantic annotation tools, detailing the contributions of semantic annotation tools in Education. Section 2.6 articulates the research findings in this chapter and identifies a set of research gaps.

2.2 Special Educational Needs (SEN) Issues: Overview

A student has special educational needs (SEN) if he or she has learning difficulties or disabilities that make it harder for him or her to learn than most other students of about the same age (Hampshire County Council, 2016; Department for Children, Schools and Families Publication, 2009; Department for Education, 2010). Whereas, Beveridge (1999) defines SEN by stating:

'Special educational need arises from a complex interaction of personal and environmental factors and may be viewed as a mismatch between the emotional, social and learning demands that are made of a pupil and the resources the pupil has to meet these demands' (p. 39).

A pupil who has a disability does not always have a special educational need. They may need extra support with daily life, but not necessarily any additional help with their learning (Norfolk County Council, 2014). Hence, special educational needs refer to a child or young person with learning difficulties, social, emotional or mental health difficulties. This could include: reading, writing, numeracy, understanding of information, sensory or physical needs, communication problems or any other medical or health conditions that may slow down their progress (Department of Education, 2006; Hantsweb, 2016). However, Special educational needs (SEN) can be complex, with children often having coexisting conditions (Carpenter, 2010). The Department of Education (DfE) (2013) has reported that about 1.6 million pupils, which is equivalent to 1 in 5, have special educational needs in the UK (Sisodia, 2013; Paton, 2014; Department of Education, 2010). Warnock (1978) clarifies that 20% of pupils have some form of SEN (Rose and Howley, 2007). Although this figure has reduced recently, it is still considered as one of the major issues discussed in the field of education. An understanding of students' individual needs could be translated into the design of appropriate technology that can be used to enhance their learning. For example, a child with a visual impairment may struggle with a whiteboard presentation, but could perhaps use a personal device at their desk to be able to see the same content or information (Department for Children, Schools and Families, 2007).

The most common issues in schools are as follows:

1 **Dyslexia/SpLD (DYL):** The word 'Dyslexia' is a combination of two Greek words 'Dys' which means difficult or painful and 'lexicos', which means words in a language, so the translation's meaning is difficulty with words (Glazzard et al., 2010; Salmon, 2012). Riddick (1996) describes dyslexia as language delay, unexpected difficulty in literacy, which includes problems in reading, spelling and writing. In addition, confusion associated with finding their bearings, understanding directions and telling the time (Riddick, 1996; Salmon, 2012; Perko and McLaughlin, 2002; Glazzard et al., 2010). Salmon (2012) describes remembering written work for dyslexic children as a common problem. There may be associated difficulties in such phonological processing, short-term memory, sequencing number skills, motor function, and organizational ability. Dyslexic individuals thrive with more of creative and visually based way of learning as they are able to think in pictures rather than words. According to the Department of Education (2006), many children with dyslexia are called 'stupid' because of their difficulties, although they are often of above-average intelligence (Salmon, 2012). Dyslexic children, however, often do not progress to their optimum potential due to the lack of support given at school (Burns, 2012).

2 **Dyscalculia (DYC):** The Department for Education (DfE) classifies dyscalculia as a condition that affects the mathematical ability in understanding the concept of numbers; students with dyscalculia may lack an intuitive grasp of figures and have problems learning or remembering facts and procedures revolving around numbers and procedures (British Dyslexia Association, 2014). A specific area of the brain is affected, which has implications on an individual's ability to understand the most basic aspects of numbers and arithmetic (Cornwall Dyslexia Association, 2011). The British Dyslexia Association indicates that 3–6% of the population are affected with dyscalculia. Students with dyscalculia incorporate colours and shapes as an aid to their learning to give a physical reality to the abstract maths (SEN Magazine, 2016).

3 **Dyspraxia/DCD**: Dyspraxia is a developmental co-ordination disorder, which affects children and adults (NHS Choice, 2014). Children with Dyspraxia require

support with speech and language in addition to language therapy (NHS Choice, 2014; Dyspraxia Foundation, 2013). It has several impacts on their daily life, including attention and concentration, behaviour, and variability in speech and language. Children with DCD frequently struggle with handwriting at school. There have been some discrepancies in the statistics surrounding the number of children with dyspraxia, with one study claiming that 1 in 50 children are affected with dyspraxia, while others claim that 1 in 12 are affected (NHS Choice, 2014).

4 **Mild Learning Difficulties (MILD):** Children with mild general learning disabilities develop at a slower rate than other children. Their speech and language may take longer to develop. They may have difficulty in forming concepts, such as colour, and in putting their thoughts and ideas into words. Some children may show a lack of coordination in motor activities, for example, hand-writing, football, skipping or tying shoelaces. It can be more difficult for these children to pay attention in class and to remember what they have learned. They may have greater difficulty transferring what they learn in the classroom to other settings. Children with mild general learning disabilities have difficulties with most areas of the curriculum in school, including reading, writing and comprehension and mathematics NCSE (2014). Some students may also display poor adaptive behaviour. The research conducted by Edyburn (2006) refers to students with mild disabilities who are unable to achieve their academic goals; these students require the involvement or incorporation of technological tools as an aid to their learning in order to complete their target work (or achieve their optimum goal) successfully.

5 **Moderate Learning Difficulties (MLD):** Students have a moderate learning difficulty if their achievement is significantly below the expected level in all or most areas of the curriculum, taking into consideration that they receive an applicable education similar to children of their age (Glazzard et al., 2010). Students with MLD specifically require additional support in literacy, numeracy and understanding different concepts from the curriculum. They may also benefit from support if required for low self-esteem, communication issues, speech and language delay and poor concentration. MLD students can also have visual impairment, hearing impairment autistic spectrum disorders (ASDs), a lack of communication skills (or poor

communication skills) and emotional disturbance (Special Education Support Service, 2014; DfES, 2003). Teachers of MLD students require support in planning, teaching and assessment process, and may use graphic and media as part of the teaching resources (Rewarding Learning, 2016). Few experimental studies have been found in which pupils with MLD have been identified and given selective teaching approaches. However, Mastropieri et al. (1997) suggested that in science, pupils with Mild Mental Retardation (MMR) may need to be told the general rule initially and then coached on the application of the rule unlike other pupils who can learn the rule inductively from the outset.

6 Severe Learning Difficulties (SLD): Severe learning difficulty (SLD) refers to children with communication and interaction difficulties combined with severe and profound learning difficulties (Davis et al., 2004). These issues could be accompanied with additional disabilities such as autistic spectrum disorders (ASDs), challenging and/or self-injurious behaviour, emotional disturbance, epilepsy, hearing impairment, physical impairment, severe impairment in communication skills and visual impairment (Special Education Support Service, 2014). Ware (1997) discusses the problematic notion of progress concerning these pupils and in what terms it is to be defined. Her review of evidence with reference to a SEN-specific pedagogy for pupils with SLD or PMLD (Ware, 1999) highlights the variety of impairments which these children may experience, the commonality of children's underlying needs and the considerable impact of personality factors such as motivation on the learning of pupils with PMLD. These pupils may possibly be receiving one or more forms of regular medication which may interfere with their learning (Norwich, Lewis, 2001). Sensory approaches have been presented by a number of writers as valuable mechanisms at the initial stages of learning.

7 Profound and Multiple Learning Difficulties (PMLD): Pupils with profound and multiple learning difficulties require an elevated level of care from an adult in their learning and their personal care. They normally have physical difficulties and tend to break the curriculum into small steps. In addition, PMLD students may also communicate by a gesture, eye pointing or symbols or very simple language (Davis et al., 2004; Glazzard et al., 2010).

8 Attention Deficit Hyperactivity Disorder (ADD/ADHD): Some of the symptoms that may accompany ADHD include hyperactive, short attention span, fidgeting and being easily distracted (Sajadi and Khan, 2011). Almost all pupils with ADHD also have concomitant learning difficulties. It is usually diagnosed between the ages of three and seven (NHS Choice, 2012). In the UK 8% to 10% of school-aged children are affected by ADHD (Kids Health, 2014), which means effectively that there are at least one or two pupils in every classroom with ADHD (O'Regan, 2002; Glazzard et al., 2010).

9 Speech and Language Difficulties (SLD): Children with speech and language difficulties (SLD) have speech, language and communication needs (SLCN). They have specific speech and/or language impairments (SSLI) or specific speech and/or language difficulties (SSLD). This affects 7.4% of the population of children (Davis et al., 2004).

10 Autism (AUT): Perko and McLaughlin (2002) define autism as a lifelong behavioural disorder that is identified within the first three years of life. Ferdig (2009) states that 1 in every 150 children is diagnosed with autism while Duffy (2013) considers autism as one of the most common neuro development disorders, which affects 1 in 88 children. Between 2005 and 2010, the number of students in the UK diagnosed with an autistic spectrum disorder has increased by 61% to 56,000 (DfE, 2011). Autistic children have language delay, which can cause problems with reading, writing and spelling. They also have problems with memory, organizational skills and their social skills (Perko and McLaughlin, 2002; Glazzard et al., 2010).

There are two types of autistic spectrum disorder, Kenner's Syndrome and Asperger Syndrome, which was identified in the 1940s. According to the Wing and Gould (1979) survey, which was carried out in South London, there are three ways in which an autistic child can be identified: firstly, through recognition of social impairments; secondly, through identification of verbal and non-verbal impairments; thirdly, through repetitive and stereotyped activities. Perko and McLaughlin (2002) call autistic an ultimate learning disability because of the difficulty in languages and social behaviour. They posit that educating students with autism is a challenge for special educational needs teachers. However, many technologies have been developed to support the education of autistic children to enable them to cope with real life. Furthermore, to educate autistic students efficiently, they need to be trained to do certain tasks. Picture Exchange Communication System (PECS), Makaton, Widgit or Sign along can be very useful for children with autistic spectrum disorder (Glazzard et al., 2010). A teacher who caters for autistic children should be structured in their approach, with excellent organised visual resources. Many children with ASD prefer the visual learning style, which encourages their teachers and teaching assistants to prepare all the resources using images or other visual aids.

11 Asperger Syndrome (ASP): The education department in 2006 described pupils with Asperger syndrome as having impairments with social interactions and communication skills (Department of Education, 2006; Shearer et al., 2006). Their academic abilities are higher than students with autism issues, and may perhaps not have any language delay. It is a hidden disability from the appearance of the child. They have difficulties in social communication, interaction and imagination (National Autistic Society, 2014). Pupils with Asperger syndrome may find difficulty in the solid understanding of mathematical thoughts, problem solving and introducing new topics. Repetition and using different ways to present the information in class, such as the use of visual aids, supports pupils with Asperger syndrome. In English lessons, pupils with Asperger syndrome typically have difficulty in interpreting text that is not written in the literal sense (BBC, 2014).

12 Multi-sensory Impairment (MSI): Those pupils with visual and hearing difficulties are considered as having multi-sensory impairment. They usually have difficulties in communication and gaining information (Department of Education, 2013). For example, children with visual impairment need to use specialist resources such as large print books and ICT resources.

13 Down syndrome (DOWN): Down syndrome is the result of having an extra chromosome in the body's genetic makeup. Children with Down syndrome have narrow eyes, a broad nose, and a tendency towards a round face. Down syndrome tends to affect the sight and hearing and can cause, or is associated with the development of, heart conditions. Children with Down syndrome learn better visually by the look and say method and can be emotionally immature (SCoTENS, 2014).

14 Cerebral Palsy (CP): Cerebral palsy is a disorder of movement, which is caused by damage to an area of the brain that controls movement. It may affect other areas as well, which can result in problems with sight, hearing and learning. Children with cerebral palsy may have a short memory, reduced concentration limit and difficulties with learning new vocabulary. Their learning will improve by using visual stimuli, such as pictures (SCoTENS Special Educational Needs, 2014).

2.3 Pedagogy for Special Educational Needs (SEN) Teaching

A recent report from the Office for Standards in Education (OFSTED, 2004) found that many schools in England and Wales still do not see themselves as having the skills, experience or resources for children with special educational needs (Rix et al., 2009). The belief in a need for special pedagogical approaches for these children has also been widely critiqued (Hart, 1996; Thomas and Loxley, 2001). An issue for teachers is the lack of useful and valid research evidence on which to base conclusions about effective pedagogy for children with special educational needs (Rix et al., 2009).

There is considerable evidence that teachers attempt to differentiate their teaching according to perceptions of broad pupil ability (Norwich and Lewis, 2001; Rix et al., 2009). Own and McIntyre (1993) stated that general and specific ability were among the characteristics which teachers perceived as important when planning teaching. Similarly, Cooper and McIntyre (1996) investigated teachers' 'craft knowledge' in relation to the teaching of 11-12 years. It was found that responses to pupils perceived as being of low ability included emphasising oral explanations, providing multiple examples, using pictorial stimuli and, for pupils with writing difficulties, providing highly structured written tasks (Norwich and Lewis, 2001). A SEN group is acknowledged as essential for distinct kinds of teaching for children to learn the same content as others without SEN. The links of effective teaching for all learners, although usually referenced indirectly or explicitly to numeracy and literacy, have been widely reviewed (Scheerens, 1989; Yates and Yates 1990; Cooper and McIntyre, 1996; Creemers, 1997; Gipps and MacGilchrist, 1999). Such reviews point to broad features of effective pedagogy, such as clarity about the purposes of a sequence of lesson instruction, clear lesson presentations, teaching in small groups, monitoring of pupils' attention and maximising learning time.

To tackle the learning challenges highlighted for those with SEN cases discussed in section 2.2, schools try a range of teaching approaches and learning styles, with a variety of activities to support their learning (Department for Children, Schools and Families, 2007; Millar, 2010). The teaching staff (teachers, teaching assistants) use images, charts, symbols, spoken words, ICT, sorting and labelling, scribing and numbers as tools to aid in teaching. Teachers use different types of resources in the classroom in an attempt to eliminate those barriers preventing the participation and achievements of SEN students (Glazzard et al., 2010). However, preparing resources for individuals, with demanding needs and a variety of issues, is a significant challenge in teaching SEN students. From reviewing the full range of SEN, children may find it difficult to use the written forms as a normal form of learning and may require alternative methods, such as visual representation (Salmon, 2012). Moreover, SEN students such as autistic children are unable to communicate via speech or they speak unclearly, which can be very difficult to understand. They may also not find the initiative to talk. It is for these reasons that these students need other means to communicate (Overcash et al., 2010). Teaching staff use visual and auditory methods with different types of resources to achieve good results (Glazzard et al., 2010). Figure 2.1 outlines the existing alternatives to written recording that are used in schools.

Some studies and reviews such as Bulgren and Carta (1992) focus on the behaviours of pupils with learning difficulties. These explain what is happening in classrooms and have shown that pupils with learning difficulties tended to be more off-task, received more teacher attention, particularly for off-task behaviour, and were given fewer academic questions, shorter response times and less feedback than were other pupils (Norwich and Lewis, 2001). The literature does not provide evidence about SEN-specific effective strategies (Lloyd et al., 1998). Consequently, it is unsurprising that special educators concluded that the efficiency of differential programmes for pupils with SEN remains without evidence (Norwich, Lewis, 2001).

Overall, the literature on teaching interventions for pupils with severe, profound or multiple learning difficulties provides some support for differences in emphases in pedagogical practice; for example, towards a greater need to check that the pupil is in a 'ready' state for learning. Possibly, this is different in degree, but not in kind, from checking, with a mainstream class, that all the pupils are paying attention when instructions are being given to the whole class. There is a need for more UK and secondary based research, and more rigorously designed studies to evaluate teaching approaches (Rix et al., 2009). Within Rix et al., (2009) research base, there is evidence that teachers are more likely to be effective with all pupils if they use language to draw out pupils' understandings, encouraging further questioning and links between new and prior knowledge. From this research review, there are other sides of teaching where additional emphasis on common teaching approaches is required, depending on the individual learning needs of those with learning difficulties. For example, children can learn concepts, gain more experience of transfer, and receive more careful checking for preparedness for next stage of learning (Norwich and Lewis, 2001). Rix et al. (2009) stated that many teachers will recognise the importance of subject specific curriculum skills, facilitated by the use of authentic tasks, accessed through varied modes, and the value of scaffolding cognitive and social skill development in ways that utilize the social engagement of the learners. It is acknowledged that teachers appreciate the need for sufficient planning and preparation time to collaborate with others in the development of curriculum activities and understanding that facilitate the learning process.

Pedagogical approaches which effectively include children with special educational needs in mainstream classrooms are not about the teacher alone, but are rooted in the community of learners and the resources required to be prepared for an effective learning. Teachers need opportunities to explore and reflect upon this view of learning and to develop pedagogies which use, monitor and develop pupils' social engagement, understanding and motivation (Rix et al., 2009).

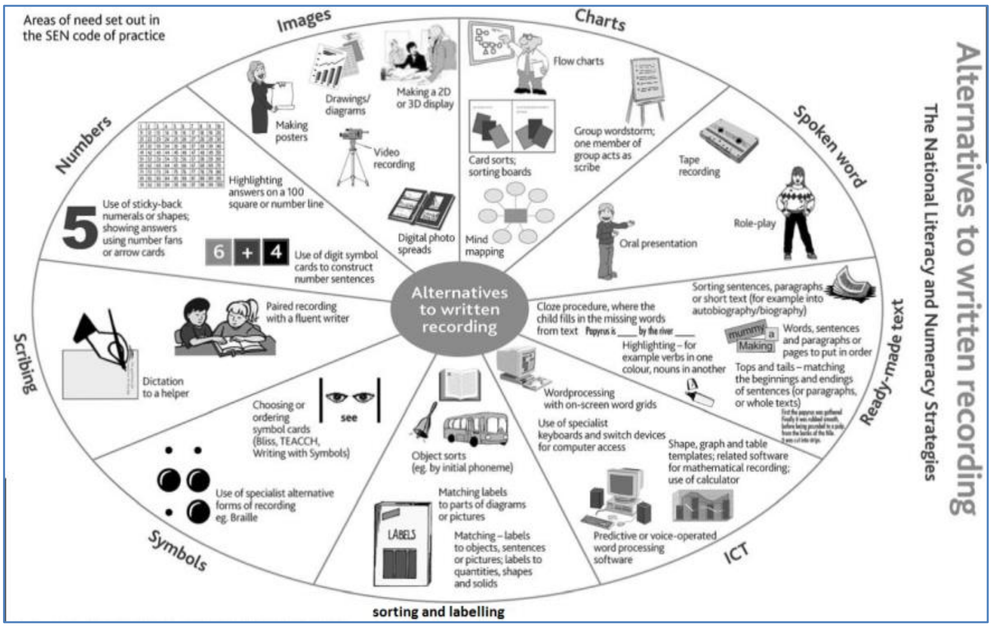


Figure 2.1: Alternatives to written recording (Glazzard et al., 2010)

2.3.1 Communication Symbol Systems.

This section reviews the communication systems that are widely used to teach SEN students in the UK, such as Makaton, PECS, Signalong, Widgit and Blissymbol. These symbol systems have been used since the 1970s to support face-to-face communication in SEN children with little or no speech ability. Examples of the types of symbol systems currently used in England are as follows:

1. **Blissymbolics**: A communication system originally developed by Charles K Bliss (1897–1985) for international communication. There are huge vocabularies, including quite sophisticated and abstract meaning. However, many symbols are not transparent or guessable although there are simple rules that help to decode the symbol shape (Millar, 2010). These symbols are used by some adult not children in UK (Millar, 2010)

2. **Picture Communication Symbols (PECS):** PECS was developed at the beginning of 1985, at the Delaware Autism Program by Lori Frost, MS, CCC-SLP, and Andy Bonday. Bonday (1994) suggested the first description of PECS, which is a communication system for children with no speech. The pupils can exchange PECS

cards with the item, or to highlight any needs they require, or to ask for permission to do any task (Frost and Bondy, 2012). Basic Vocabulary of 3000+ and now several 'Addendum' packs with about 2000 more symbols bring vocabulary up to 6,000+. The most commonly used symbols in education and as general 'visual environment'. Advantage of this is that staff tends to be familiar and supported with this system (Millar, 2010).

3. **Makaton**: Makaton was developed by Margaret Walker in the 1970s. It is a language communication system that uses sign language and symbols with the incorporation of speech (Ford, 2006). It supports understanding and short-term memory with the assistance of the black and white symbols. Makaton aids all SEN forms across all ages with communication problems combined with profound, severe, moderate, mild learning difficulties, autistic disorder, profound-severe physical impairment, sensory impairments and specific language disorders (Mandy and Brown, 2012). Makaton is used to support spoken language for adults and children with signs, symbols and speech. It can help in communication, understanding, concentration and remembering sequences (CBeebies, 2014; Sheehy and Duffy, 2009). Most popular starter is bundle £155 of core, transport and animals, and National Curriculum (Millar, 2010).

4. **Widgit**: The Widgit Literacy Symbol, also known as 'Widgit Rebus' was adapted from the original Rebus symbols and was first developed in the UK by Oosterm and Devereux (1982). It provides visual images that can support text and clarify the meaning of the words and actions. It is an aid that has been used for people with learning and communication difficulties for over 30 years. It can add visual support to the printed word, which can support reading and writing for individuals with special needs (Widgit, 2014). Pupils who operate more visually can benefit from this type of communication to express themselves, and improve their learning outcome (Widgit Software, 2005). There are around 8,000+ symbols available rooted in UK culture (Millar, 2010). They are widely used across England and Wales.

5. **Signalong**: A communication system based on British Sign Language signs. People with different types of difficulties and disabilities can use sign supported

communication like Signalong. This language can be used for children with autism, language delay and Down syndrome (Communicating Choices, 2013). Table 2.1 introduces examples of the types of symbols currently used in UK.

Symbol systems can be a vital learning and communication tool for students with physical and communicational difficulties. However, there are different types of systems, which represent symbols in different ways with huge amount of vocabulary cards, as illustrated in Figure 2.2. This leads to extra effort on the part of the teaching staff to learn the system used in each school. Furthermore, as reported by Millar (2010) all the special need resources are expensive.

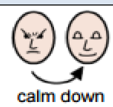
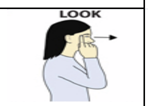
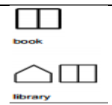
Symbol Developer	**Information about the symbols**	**Example Symbol**
Widgit Software – Widgit Literacy Symbols www.widgit.com	Supports face-to-face communication for those with little or no speech development or literacy. Supports language development for those with moderate and severe learning difficulties.	
PECS www.mayer-johnson.com	Originally a picture dictionary to fill a need for a transparent set of symbols. Originally for communication, now used for educational purposes.	
Makaton - Makaton Symbols www.makaton.org	For children and adults who are developing literacy skills. To teach communication, language and literacy skills.	
Signalong http://www.signalong.org.uk	Signalong focuses on developing communication skills rather than teaching blocks of signs. Most users have learning disabilities or autism spectrum disorders.	
Bliss Symbols www.blissymbolics.org/	Black and white only (may use colour-coded background). Many symbols are not 'transparent' or guessable though there are simple rules that help you decode symbol shape.	

Table 2.1: Information about symbols used in the UK

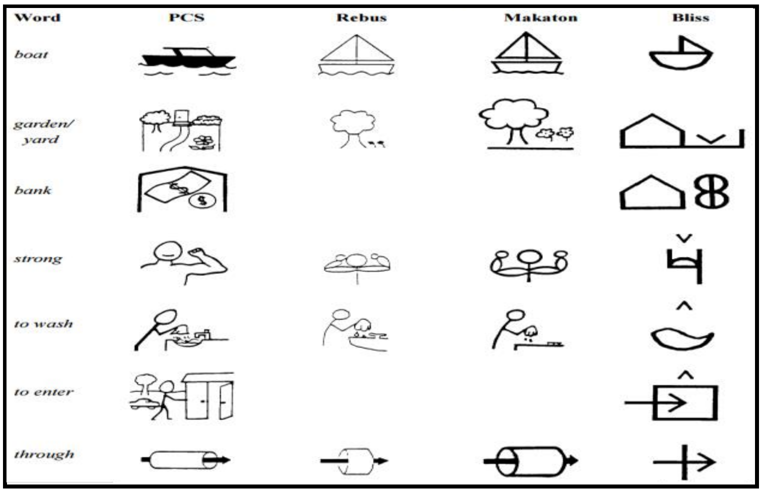


Figure 2.2: Comparison of symbol systems

2.3.2 Facilitatation of Teaching SEN Students with Visual/Audio

Vision is often regarded as the most important perceptive modality during interaction with the environment in daily life. Hence, In the field of motor learning, visual learning strategies such as learning by video demonstration are well established (Sigrist et al., 2013). Video is very common in teacher training since it allows users to capture audiovisual images. The student or the teacher observes their own experience through the video and they reflect on it in the classroom (Pérez-Torregrosa, Díaz-Martín, and Ibáñez-Cubillas, 2017). Also, auditory perception contributes to elite performance in sports auditory information about the ball bouncing on the table and racket (Hermann, Honer, and Ritter, 2006). Similarly, Towers (2007) explored the potential offered by video material to adopt the belief that teaching is a learning activity. This study includes advantages and limitations of video as a teaching tool.

For SEN students, visual learning encourages the use of visual aids such as images, video or cards to deliver educational contents. It is a great way of special need learning, because it increases the learner's interest in certain subjects, making the learning process more enjoyable and retaining the student's interest for a longer period, which leads to the enhancement of the learning process (Zane, 2015; Burgstahler, 2011). Furthermore, learning, for visual learners, takes place all at once, with large chunks of information. For example, they can learn all the topics as a related set of images much more easily and faster than struggling with a text or cards independently, as explained by Zane (2016), and demonstrated by one child who asked: 'I can't think of the word; can I draw a picture?' (Widgit, 2016).

Visual learning techniques are used widely in schools to accomplish curriculum goals and improve students' performance (Deliyannis and Simpsiri, 2008). The Institute for the Advancement of Research in Education (IARE) at AEL has completed a research of twenty-nine studies, which provides evidence of the instructional effectiveness of using visual learning techniques (Zane, 2016). The learning theory assumes that students have a dominant channel (visual, auditory or kinaesthetic channel) through which they learn most effectively. Based on this premise it is assumed that if learning takes place using the dominant channel then learning will be more effective (Glazzard, 2015). Scientifically based research also cites that visual learning techniques can improve student learning and performance in the following areas: reading, comprehension, and students' achievement across grade levels, diverse student populations and content areas (Glazzard et al., 2010). Moreover, without the significant use of visual learning, many students under-perform because of the inconsistencies between teachers, teaching styles and students' learning styles. The learning outcomes can be improved with an improved balance between verbal and visual techniques. However, Deliyannis and Simpsiri (2008) reported an analysis which indicated difficulties in utilising manual application of symbol system as customization to individual student-needs is always needed. It present complex and time-consuming task to educator. Sound can also be used to special need learning, as noticed by Bishop and Sonnenschein (2012). The use of sound is effective in seizing attention in general (Bishop and Cates, 2001). Different sounds can be used to refer to various things such as the alarm clock, sounds of different animals, environmental sounds such as wind and rain, etc. Bishop and Sonnenschein (2012) point out the link between sound and the learner's attention in class and suggest that sound can be used to grasp attention for a period of time. The focus in their study is that instructional designers should consider adding the auditory sense in their presentation as one of the main factors to enhance pupils' learning.

2.3.3 Facilitate Teaching SEN Students with ICT Technologies

ICT is a very important tool in the support and facilitation of learning and teaching for both SEN students and the teaching staff, who may use ICT for the internal preparation and targeting of differentiated learning resources (Ace Centre Advisory Trust, 2001). For some students, technology may be the only way to ensure they can make their thoughts and needs known. For them, access to appropriate ICT-based solutions provides perhaps the only chance of participating in society and realising their full potential (Becta, 2003). For example, the use of information technology in e-learing provides several advantages compared to traditional classroom setting. However, there are some limitations of e-learning, such as student's discomfort and anxiety. These possible disadvantages may have a significant influence on learners' learning effectiveness. (Jashapara and Tai, 2011; Zhang, Zhao, Zhou, and Nunamaker, 2004). Using ICT in teaching SEN students has an effective input, as reported in Becta (2003), which unlocks hidden potential for those with communication difficulties, enables students to demonstrate achievement in ways that might not be possible with traditional methods, and enables tasks to be tailored to suit individual skills and abilities. At SEN schools, a range of ICT equipment may be used, with interactive whiteboards being commonly used. Special needs children usually use portable personal technologies, such as laptops and other portable battery-operated writing and speech output devices, in addition to more traditional methods. They might also have one or more specialist devices to help them access ICT, including audio-visual equipment.

Audio-visual equipment includes PECS for children with autistic spectrum disorders, electronic Voice-Output Communication Aids (VOCA) (need battery maintenance, screen magnifiers for those with a visual impairment), digitised or synthesised sound to be used with symbols and pictures (Department for Children, Schools and Families, 2007). In addition, there are some projects that offer a large amount of information and examples about symbol systems, such as www.symbolsinclusionproject.org. This type of system improves behaviour and motivation, offers accessibility of the curriculum and provides strategies to enable students to demonstrate what they know (Widgit, 2016). While such systems cover information about the school curriculum and provide various suggested ways to teach SEN students, to use the system for teaching is expensive. The provision of standard, mainstream software, without adaptation, will have little impact on the ICT success of pupils with severe and complex needs (Widgit, 2016). Hence, there are special needs software provide this requirements that can be adapted to suit individual needs. The spectrum ranges from a variety of cause-and-effect softwares (e.g. SwitchIt!, Maker), to versatile, alternative frameworks for writing and learning (e.g. Clicker 3 and 4) (Ace Centre Advisory Trust, 2001).

For pupils with emotional and behavioural difficulties, there is a range of ICT resources that can motivate and challenge such pupils. These include multimedia programmes and educational games. Furthermore, pupils with learning difficulties may use talking books and other CD-ROMs with good sound and graphics (Talent, 2004). Using any of the previous methods requires investment from the school in purchasing them, and they are expensive. Also, some schools have a limited budget that prevents them from buying software in addition to the equipment required. Also, these applications are standardised and the teaching staff cannot share or add any additional teaching material as required without a cost implication. The World Wide Web (WWW) has new ways of accessing electronically available information. Rapid evolution of the World Wide Web with its underlying sources of data, knowledge, services and applications continually attempts to support a variety of users, with different backgrounds, requirements and capabilities. In such an environment, it is highly unlikely that a single user interface will prevail and be able to fulfill the requirements of each user adequately (Bell, Heravi and Lycett, 2009). The WWW, at present, contains billions of static Web pages, accessed by millions of users around the globe. However, this tremendous quantity of information has facilitated the increasingly difficult problems of finding, accessing, presenting and maintaining the information needed by different users (Alam et al., 2015). Thus, a considerable gap has emerged between the information available for tools aimed at teaching students and the traditional teaching methods described above when used in teaching SEN students. The Semantic Web extends the World Wide Web by transforming the Web into more machine processable, and intelligent Data (Alam et al., 2015). In addition, the literature review reveals that there is an increasing interest in developing the use of the Semantic Web in teaching students at various stages of education. This technology allows the computer to understand the data, enables the sharing of teaching materials, and allows the teachers to edit any piece of teaching material.

2.4 Semantic Web (SW) Technology

‘The Semantic Web is a vision: the idea of having data on the Web defined and linked in such a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications. (Nagarajan, 2006).

The Semantic Web is an evolving extension of the current web, in which information is given well-defined meaning (Kashyap et al., 2008; Berners-Lee, Hendler and Lassila, 2001) that allows an automatic processing of the Web. The Semantic Web facilitates sharing the explicit semantics of information in a machine-readable form (Berners-Lee et al., 2001; Antoniou and Harmelen, 2008; Berners-Lee and Cailliau, 1990; Berners-Lee, Hendler and Lassila, 2002). It enables machine to interact efficiently with data and perform various tasks such as searching, managing and combining semantically annotated information (W3C, 2011). All the data are well defined and linked, so that machines can understand them, in addition to automation, integration and the ability to reuse the data within different applications (Kashyap at al., 2008). The semantic technology is adopted in various disciplines including education (Berners-Lee and Cailliau, 1990; Daconta, Obrst and Smith, and 2003). Semantic Web technologies provide more powerful means of defining concepts and their relationships in a domain, which results in more clarity and less ambiguity in the domain model. Semantic Web technology is now one of the main topics in the computer science literature (Maddux et al., 2011). It is based on Resource Description Framework (RDF), and in 2008 the W3C produced SPARQL, which is the key standard for opening up data on the Semantic Web (SW) (Gutierrez, 2008). The potential of the Semantic Web (SW) encourage many researchers to investigate its effect on their fields of interest (Gutierrez, 2008). The architecture of the Semantic Web (SW) is shown in Figure 2.3, which is used in this research to develop a model.

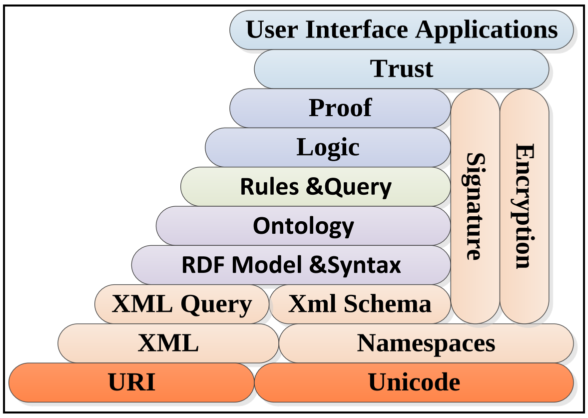


Figure 2.3: Semantic Web Stack (Alam et al., 2015)

Dumbill (2001) states that: 'we should be careful not to restrict Semantic Web technologies to just those explicit layers in Berners-Lee's idealized diagram'. The bottom layers contain technologies providing common syntax. Uniform Resource Identifier (URI) provides the means for uniquely identifying resources (entities) (Berners-Lee et al., 2001), while Unicode serves to represent and manipulate text in many languages, which is useful for exchanging symbols. The Extensible Markup Language (XML) is a markup language that enables the creation of documents composed of structured data, while XML Schema allows the definition of grammars for valid XML documents. The Semantic Web gives meaning (semantics) to structured data. XML documents can refer to different namespaces to make explicit the context (and therefore meaning) of different tags. XML Namespaces provide a way to use markups from more sources. The Semantic Web aims to connect data together, which needs to refer to more sources in one document. As Figure 2.3 illustrates, the architecture comprises the resource description framework (RDF) triple store, dynamic content engine, artificial intelligence (AI) application and browser (Alomran, 2014).

2.4.1 The Components of the Semantic Web Technology (SW)

The basic components of the Semantic Web (SW) consist of metadata, the Semantic Web (SW) languages, ontologies, the semantic mark-up of pages and services (Devedzie, 2008). They can be summarised as follows:

1. **Metadata** is one of the factors that can have an impact on the Semantic Web (SW) (Guns, 2013). It is information about information or data about data, which means data, describes another piece of data (NISO Press, 2004). The importance of metadata has also evolved to include the domain of the Semantic Web. At the heart of the Semantic Web is the idea of adding formal metadata that describes the context and/or structure of a Web resource (Al-Khalifa and Davis, 2006). A number of organizations are involved in producing metadata standards specifically for learning technology (Robson, 2000). Metadata standards are formal specifications used to semantically annotate educational materials of any kind (Stratakis et al., 2003). Some developers consider the metadata as the heart of e-learning (Sammour, 2006). E-learning covers a wide set of applications and processes, including Web-based learning, computer-based learning, virtual classrooms and digital collaboration. The metadata is useful because it provides an area for keeping data about any e-learning resource (CourseAvenue, 2007). Alomran (2014) shows the benefits of using Semantic Web technology for e-learning, as illustrated in Table 2.2. Each learning material must be described or 'enriched' with the following metadata information:

- What is the learning material about (content annotations)?
- Which is the context of the learning material (context annotations)?
- How is it connected to other learning materials (structure annotations)?

Characteristics	**E-learning**	**Semantic Web**
Delivery	Pull: student determines Agenda	Knowledge items (learning materials) are distributed on the Web, but they are linked to commonly agreed ontologies, which enables the construction of a user-specific course via semantic querying for topics of interest.
Responsiveness	Reactionary: responds to problem at hand	Software agents on the Semantic Web may use a language that enables coordination between agents and the proactive delivery of learning materials in the context of actual problems.
Access	Non-linear: allows direct access to knowledge in whatever sequence makes sense to the situation	Users can describe the situation at hand and perform semantic querying for the suitable learning material. The user profile is also accounted for, and access to knowledge can be expanded by semantically defined navigation. An example student, teacher.

Characteristics	E-learning	Semantic Web
Symmetry	Symmetric: learning occurs as an integrated activity	The Semantic Web (semantic intranet) offers the potential to become an integration platform for all business processes in an organisation, including learning activities.
Modality	Continuous: learning runs parallel to business tasks and never stops	Active delivery of information (based on personalised agent) creates dynamic learning environments that are integrated in the business processes.
Authority	Distributed: content comes from interaction of participants and educators	The Semantic Web will be as decentralised as possible. This enables effective cooperative content management.
Personalisation	Personalised: content is determined by individual users' needs and aims to satisfy all users' needs.	A user (using his or her personalised agent) searches for learning material that is customised to his or her needs. The ontology is the link between users' needs and characteristics of the learning material.
Adaptively	Dynamic: content changes constantly through user input, experiences, new practices, business rules and heuristics.	The Semantic Web enables the use of distributed knowledge provided in various forms, enabled by semantic annotations of content. The distributed nature of the Semantic Web enables the continuous improvement of learning materials.

Table 2.2: Benefits of Semantic Web Technology in E-Learning (Alomran, 2014)

2. Semantic Web (SW) Languages: Semantic Web (SW) Languages form the core ontology language and simple models are used for combining data and representing information on the Web. They are typically based on the Resource Description Framework (RDF), which could be represented as a labelled graph (Devedzie, 2004; Drummond, 2005; Berners-Lee, 2009; Ghaleb et al., 2006; Allemang and Hendler, 2008) and is based on XML (eXtensible Markup Language). RDF allocates Universal Resource Identifiers (URIs) to its individual fields, which are used as a graph node to identify what the node represents or to predicate and identify a relationship between nodes (Shadbolt and Hall, 2006). Resources are described using RDF statements, which are represented as Subject, Predicate and Object as described in Figure 2.4. Therefore, a single triple is a statement that a subject (e.g. a Person, a Car, a Web Site) stands in a specific relationship (e.g. 'is brother of'; 'is driven by'; 'is authored by') to an object (e.g. a person, website) (Brickley and Guha, 2004). The extended ontology language to RDF is RDFS (Antoniou and Harmelen, 2008). It allows classes of resources and properties to be included. The RDF schema lacks the ability to express complex and richer relationships between classes. It is extended to cater for the new features by adding new paradigms for expressiveness, thereby leading to a richer ontology language.

Ontology Web Language (OWL) is knowledge-representation mark-up language that process information contents besides presenting them to the users. OWL is syntactically layered on top of RDF and RDFS. It facilitates defining domain ontologies to support the aspects of intelligent pervasive computing (Smith, Systems, Welty and Mcguinness, 2004; Antoniou and Harmelen, 2009). OWL has the ability to express the semantic of entities better than XML, RDF and RDF-S due to its ability to structure specific knowledge in a given domain hierarchically. Consequently, it can be analysed and understood by the machine easily because it can represent machine interpretable content on the Web. OWL extends RDF with additional vocabulary that can be interpreted as OWL ontologies when used to form particular RDF graphs. Moreover, it has larger vocabulary than RDF, formal semantics, and stronger syntax. Furthermore, OWL can specify exact description of resources on the Web, and also gives high interpretation power to software applications.

Three kinds of syntax classes are available in the OWL language: OWL-Lite, OWL-DL and OWL-full (Yu, 2007). The components of OWL are Classes, Properties, and Individuals (Tauberer and Elin, 2009). Implementation of semantic description with OWL is possible by specifying concepts and relationships between concepts (Koper, 2004).

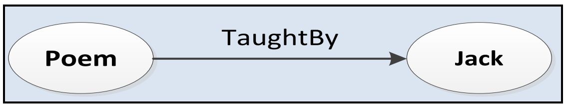


Figure 2.4: Representation of RDF Statement

3. Ontology: Ontologies refer to the basic blocks for the Semantic Web (SW), and the structure composed of relationships, as well as vocabulary that most often revolve around a particular domain (Sharman et al., 2007). Fensel and Bussler (2002) define ontologies as a formal consensual specification of conceptualisation, which can be used to provide a shared and common understanding of a given domain and provide a way of defining concepts and the relationships between them (Handschuh et al., 2001; Gruber, 1993). Conceptualisation is further defined as the intended models within which a set of logical axioms are designed to account for the intended meaning of vocabulary (Guarino, 1998). Ontologies provide a formal description of concepts and their relationships within a domain (W3C, 2011), which results in a shared understanding. Ontologies may be considered to be the bridge between real-world semantics and formal semantics and provide models of the world that reflect reality as perceived by human beings (Fensel, 2001). The basic components of ontology are classes, properties and restrictions (Sachs, 2006). Classes group resources with similar characteristics according to W3C recommendation. There are two types of properties: object properties, which link individuals to individuals; and datatype properties, which link individuals to data values. Restrictions are all the conditions provided, such as a query. Davedzie (2004) clarifies that the ontology can be used as a tool to help in sharing and reusing knowledge. Ontologies can be very useful for a community as a way of structuring and defining the meaning of the metadata that is currently collected. They can also be used to provide semantic annotations for collections of images, audio or other textual objects. Moreale and Vargas-V (2004) demonstrate that ontologies can be used as a tool in e-learning to describe the organization of universities and courses. For example, the main activities in an e-learning environment are providing information from authors and accessing learning materials by readers and authors by querying and browsing. Ontologies can be created and maintained by using different tools such as Protégé ontology editor which supports the definition of concepts hierarchies, the definition of attributes for concepts, and the definition of axioms and constraints (Horridge et al., 2004).

4 Semantic Web Services (SWS): A Web service is defined as a software system that is identified by a URI. URI public interfaces and bindings are defined and described using XML. All the input and output parameters of the Web service are XML documents. The key principle of SWS is the use of ontologies to describe different service elements in a precise, shared and semantically rich manner. Web services are described by WSDL language, which is developed with semantic annotation by different languages such as SAWSDL. This language provides more information about the behaviour of the Web service and simplifies their management (Sellami and Rodriguez, 2012). SOAP, WSDL, and UDDI are technologies for transporting data over the Web (Anura, 2004; Rudi and Andreas, 2007). The Web service allows the communication between data through the internet, allowing the sharing of data from a server application to a desktop.

2.5 The Semantic Annotation

Annotation is a significant process in the area of the Semantic Web, which adds semantic annotations to Web documents in order to access knowledge instead of unstructured material (Alomran, 2014). This allows knowledge to be managed in an automatic way.

Semantic Annotation is the process of annotating resources with semantic metadata document (Kahan et al., 2002; Moreale and Vargas-V, 2004; Nagarajan, 2006). Azouaou et al. (2004) defined the semantic annotation tool as a note added by way of comment, explanation or the act of annotating. This definition, as do many definitions from research literature, specifies that an annotation is both an object added to a document and the activity that produces this object. The semantic annotation refers to the allocation of an entity (a string, a sentence, a paragraph, part of a record or document) to metadata whose semantics are often defined in a model. This metadata can be stored in the document itself, or in another document referencing the entity annotated by URI (Universal Resource Identifier) (Oriche et al., 2013; Moreale and Vargas-Vera, 2004). The process of associating metadata with resources (audio, video, structured text, unstructured text, Web pages, images, etc.) is called annotation (Hassanzadeh and Keyvanpour, 2011). Annotation ensures that there is precise, machine-understandable and shared meaning by the referencing of these resources to appropriate concepts in shared ontologies (Oriche et al., 2013). Euzenat (2002) suggested that an annotation is a content represented in a formal language and attached to the document. It facilitates the access and use of information on the World Wide Web (Yang et al., 2004).

2.5.1 Semantic Annotation Tools

The Semantic Annotation Tool is a software tool that allows the insertion and management of semantic annotations accompanying a given information resource (Oriche et al., 2013). Recently, many annotation tools have been developed, which are manual, semi-automatic or automatic. Uren et al. (2005) refers to two frameworks for annotation in the Semantic Web (SW): the W3C annotation project Annotea, and CREAM. Annotea is a W3C project whose main format uses RDF, and the documents that can be annotated are limited to HTML or XML-based documents. However, it provides an **XPointer** for locating annotations within a document. An XPointer is a W3C recommendation for identifying fragments of URI resources. While the component of a document to which an XPointer refers is retained, the location of the associated annotation will be robust to changes in the detail of the document. However, if large scale revisions are made, annotations can easily come adrift from their anchor points. Annotea approach concentrates on a semi-formal style of annotation, in which annotations are free text statements about documents. These statements must have metadata (author, creation time, etc.) and may be typed according to user-defined RDF schemata of arbitrary complexity. Given the previous discussion, Annotea is not quite as formal as would be ideal for the creation of intelligent documents. The storage model proposed is a mixed one, with annotations being stored as RDF held either on local machines or on public RDF servers.

On the other hand, CREAM looks at the context in which annotations could be made and used as well as the format of the annotations themselves. It specifies components required by an annotation system including the annotation interface, with automatic support for annotators, document management system and annotation inference server. Like Annotea, CREAM subscribes to W3C standard formats, with annotations made in RDF and XPointers used to locate annotations in text. This can, however, restrict it to Web-native formats such as XML and HTML. Unlike Annotea, the authors of CREAM have considered the possibility of annotating the deep Web. This involves annotating the databases from which deep Web pages are generated so that the annotations are generated automatically with the pages. As databases hold much of the legacy data in companies, this is a substantial addition. It is supported by a storage model that allows users to choose whether they want to store annotations separately on a server, embedded in a Web page or on a separate server. This assumes greater user control of the document and recognizes that users may prefer to store annotations with the source material. The CREAM framework allows for relational metadata, defined as ‘annotations which contain relationship instances’. Relational metadata is essential for constructing knowledge bases that can be used to provide semantic services. Uren et al. (2005) gave examples of tools based on the CREAM framework, such as OntoMat-Annotizer, and the Annotea framework, such as Amaya. Slimani (2013) described the process of manual annotation as an expensive, time consuming, difficult task which requires comprehensive human involvement. However, it is user friendly GUI, accurate and easy-to-use, especially for those with limited skills, as opposed to automatic annotation (Sellami and Rodriguez, 2012). To compare the annotations, automatic or semi-automatic techniques have been proposed (Sellami and Rodriguez, 2012). Users with limited ICT skills who are unfamiliar with the syntax of the language find semi-automatic techniques difficult to use (Salih, 2013). One of the key problems with manual annotation is that a person is required to annotate the resources and not many users are willing to do this. Therefore, alternative approaches should be considered, including semi-automated or fully automated systems (Moreale and Vargas-Vera, 2004). Figure 2.5 describes a Generic annotation model, and Figure 2.6 describes The Tag Annotation Model based on Andrews et al. (2011) model.

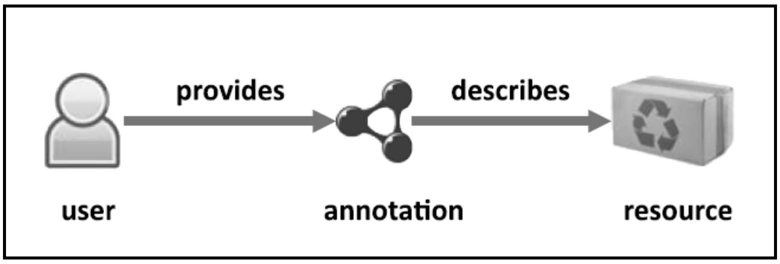


Figure 2.5: A Generic Annotation Model

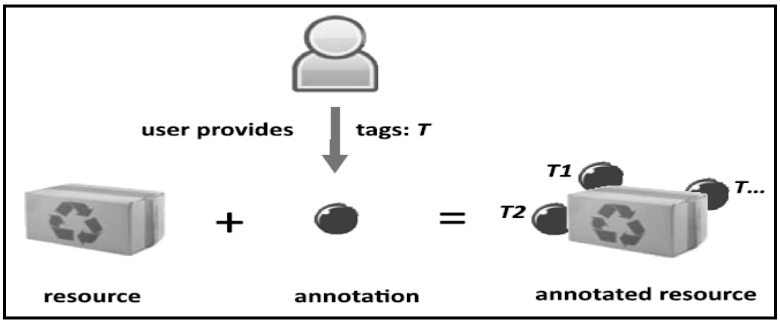


Figure 2.6: The Tag Annotation Model

From the extant literature, there are different types of annotation tools as illustrated in Table 2.3, which compares annotation tools from different aspects. This research concentrates on two annotation tools.

Annotation Tool	**User-Centred Design**	**Ontology Support**	**Document Evolution**	**Annotation Storage**
Amaya	Web browser, editor	Annotation server	XPointer	Local, annotation server
Mangrove	Graphical annotation tool			RDF database (Jena)
Vannotea	Collaboration support			Annotation server
OntoMat	Drag/drop, create, annotate	Onto broker annotations inference server	X pointer, pattern matching	Annotation server, embedded in Web page, separate file
M-OntoMat Annotizer	Extraction of visual descriptors			Annotation server
SHOE Knowledge Annotator	Prompting	Ontology server		Embedded in Web page
SMORE	Web browser, editor	Ontology server, editing		
Open Ontology Forge	Web browser, drag, drop, create, annotate	Local, editable ontologies	Xpointer	Local RDF or XML file
COHSE Annotator	Plug-in for Mozilla and Internet Explorer	Ontology server	Xpointer	Annotation server
MnM	Web browser	Ontology server	Store annotated page	Embedded inWeb page
Melita	Control IE intrusiveness	Local, editable ontologies	Regular expressions	
Parmenides		Additions based on clustering		RDF triple store
SmartWeb				RDF Knowledge base
PANKOW	CREAM			
AeroSWARM	Web Services	Local ontologies		
KIM	Various plug-in front ends	KIMO		RDF Knowledgebase
Rainbow Project	AmphorA XHTML database	Shared upper level ontology		RDF repository (Sesame)

Annotation Tool	User-Centred Design	Ontology Support	Document Evolution	Annotation Storage
h-TechSight	KM Portal	Ontology editor, dynamics metrics		Tagged HTML Web server
AktivDoc	Integrated editing environment			RDF triple store
Magpie	Web browser plug-in			
Thresher	Haystack semantic browser	Ontology personalization		

Table 2.3: Comparison of Metadata Tools (Kashyap et al., 2008)

2.5.2 Amaya

Amaya is an annotation tool developed by W3C in 1996 (W3C, 2014) to create and update documents directly onto the Web. It is a complete Web browsing and authoring environment which includes a collaborative Annotation application tool; Amaya annotates a Web document without editing it (W3C, 2008). It has a great deal in common with purely textual annotation tools but provides some support for ontologies. W3C proposed a Web-based shared annotation system based on a general-purpose open RDF infrastructure in 2001, called Annotea (Kahan, 2001). The user can employ Amaya to browse the content and make annotation through Annotea. This annotation can be stored either on annotation severs or at the stand-alone computer.

To associate the annotation with web content, Annotea uses XPointer technology to insert annotation position within XML documents (Kashyap et al., 2008), implying that the initial state of web content is modified after adding the annotation. A 'Pencil-Icon' appears to indicate that an annotation exists. To share other annotations, Annotea provides a discussion board-like mechanism, which allows people to review other opinions. W3C define annotation as comments, notes, explanations, or other types of external remarks, which are attached to a Web document or a selected part of the document in the Amaya project (Yang et al., 2004). It is a manual application, which does not require complicated technical skills, is easy to use, and the software is available as freeware from the internet. It allows users to browse and author Web pages, which will be uploaded onto a server. Amaya started as an HTML + CSS style sheets editor and can work on several documents with different formats, such as (X)HTML, MathML and SVG (Kahan, 2002). It includes a collaborative annotation application based on Resource Description Framework (RDF), XLink, and XPointer. It can maintain a consistent internal document model, which allows the display of the document structure at the same time as the formatted view. The Annozilla browser supports Amaya by making the annotation readable in the Mozilla browser and supports the developments of Amaya (Kashyap et al., 2008). Amaya is an annotation tool that allows the user to make annotations via the same tool they use for browsing and for editing text by mark-up Web documents in XML or HTML. It is a good example of a single point of access environment (Kashyap et al., 2008; Slimani, 2013). Given the previous literature on Amaya, it is convenient to test its applicability to use in schools for SEN students. As acknowledged any application to be used in the school environment must be user-friendly, easy to maintain and edit, and accurate, in order to avoid any class disturbance.

2.5.3 OntoMat

OntoMat annotizer is a Semantic Web annotation tool developed for authoring and annotating Web pages (Jung et al., 2006). It has a rich GUI with special pane for ontology viewer, attributes and object properties. It is based on the CREAM framework (Kashyap et al., 2008), and can support manual and semi-automatic annotation tools that would benefit from the structure of the ontology, available on the internet. The HTML browser is used for the display of the document as HTML page, Annotation or the deep Annotation associated with pages generated from databases. OntoMat allows the annotator to highlight relevant parts of the Web page and create new instances via drag-and-drop interactions (Handschuh, 2001). The research extension on OntoMat aims at the creation of M-OntoMat-Annotizer that supports manual Annotation of images and video data (Uren et al., 2006)

OntoMat annotation requires less time and effort but more technical skills in comparison to Amaya manual annotation (Dawod and Bell, 2011). A Web browser displays the page being annotated and provides user-friendly functions, such as drag-and-drop creation of instances and the ability to markup pages while they are being created (Kashyap et al., 2008). Various literature suggested that the semi-annotation tool ‘OntoMat annotizer’ is suitable for testing its applicability to be used within the SEN domain as it can be quicker, more accurate and easy to use than other similar products.

2.5.4 Semantic Annotation Tools Utilisation in Education

A considerable amount of literature has been published since 1990 on applying artificial intelligence to the domain of education (Devedzic, 2006). Devedzic (2006) described education as a rich ground for applying Web technologies and believes that the Semantic Web is the best way to improve Web-based education. Some research details that the Semantic Web can be used to support education through using different types of applications, as illustrated from the literature in Table 2.4. Koper (2004) noted that semantic annotation can support education through supporting teachers in performing their tasks online and in lifelong learning. A review of many research papers highlights the significant impact that semantic annotation has had in education. For example, Moreale and Vargas-V (2004) and Azouaou et al. (2004) investigated how semantic services can support e-learning for students and staff, and for assessing students’ work. Aroyo and Dicheva (2004) presented and analysed the main aspects of the development of a homogeneous e-learning Web space, where various systems collaborate their efforts to satisfy the users’ needs whilst using state of the art Web technologies. This brings e-learning to the level of modern society developments. Similarly, Yu, Pedrinaci, Dietze and Domingue (2012) explored how linked data can be used to annotate and search educational video resources for supporting distance learning. Furthermore, Rogozan and Paquette (2005) discussed an approach that used skills/performance and learning-domain ontologies to annotate resources in a standard manner, and proposed a framework for managing ontology changes. In contrast, Hassanzadeh and Keyvanpour (2011) discussed the obstacles associated with the use of semantic annotation, such as multilinguality, scalability, issues relating to diversity, and inconsistency in the content of different Web pages. Hence, they suggest a dynamic environment that semantic annotation systems must be performed on. They suggest machine-learning approaches such as supervised learning, semi-supervised learning and active learning. Most learning systems use tailored courses; they require teachers to specifically create each document used by the system. Teachers are provided with authoring tools (Brusilovsky, 2003) to create new documents, but this requires significant work and imposes major constraints upon the author.

Sylvain et al. (2005) stated that working with applications of semantic web technologies for e-learning systems is quite difficult. Sylvain et al. (2005) proposed a methodology for reusing document content and displaying it in a Web Based Learning System (WBLS) without relying on a specific annotation tool with form-based annotation. In contrast, Yang et al. (2004) stated that annotation can benefit learning in the following categories: (1) Attention: by helping students to focus on the annotated concept or specified sentence. (2) Discussion: by assisting students in class to discuss assignments based on different topics in an efficient manner. (3) Organization: by helping students to build their knowledge based on annotations, reminding them of important concepts. (4) Indexing: by using a bookmark to indicate the annotated objects, using an anchor to bind the annotation to the annotated object and facilitating personalized knowledge discovery given by information retrieval.

Although many studies have been conducted in the area of education, as depicted in Table 2.4, there is much work required in this field in order to use it practically. Devedzic has conducted various studies with regards to Semantic Web technology (Devedzic, 2004), and posits that the Semantic Web has limited impact on education. Devedzic reported in his paper in 2016 that there is still more work required to achieve the full use of semantic web as predicted in 2004. A diagram in the same paper shows how enthusiasm for the Semantic Web in education has changed over time. Similarly, Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas (2017) discussed the use of video tools in teacher training and reviewd all the relevant studies. These studies included research articles and conference proceeedings. The review covered all the authors studying how video annotation improves teaching and suggested a significant potential in teaching. Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas (2017) suggested that studies on video annotation in teacher training are new in this area.

'the time when many of us who have jumped on the Semantic Web train in the late 1990s believed that the Semantic Web will happen in a foreseeable time and will

transform everything, including education'; asking in the same study, *'Will the Semantic Web ever happen, in general, and specifically in education?, the best answer I can give you is 'I don't know', but I know that today we are still far away from the hopes that I had when I wrote my paper Education and The Semantic Web (Devedzic, 2004) more than 10 years ago'(Devedzic, 2016)*

For SEN interventions, the curriculum for children with special needs should be comprehensive and include programs for communication, cognitive skills, and social and behavioural skills (Koegel, Koegel, and Dunlap, 1996). The curriculum needs to include behaviours that are frequently required in each lesson. For example, educating an autistic student involves deciding what to teach and include within their curriculum (Sansosti, Powell-Smith, and Kincaid, 2004). Several areas could be addressed such as academic skills, self-help skills, social skills, vocational training, or behavioural skills (The Association for Science Education, 2015). It is important to assess each child individually because not all children with autism need the same skills (Armstrong, 2013). Motivating children with SEN to want to learn presents an interesting problem for educators (Győrfi and Smythe, 2009). It demands creativity on the part of the teacher. Another challenging aspect of schooling students with SEN is decreasing disruptive behaviours. This is often necessary since children with SEN usually have some sort of excessive behaviour which disrupts the learning process. Next, communication is a basis for learning and without intervention many students with SEN will not develop an organized language system. Initially, for autistic child, it is essential to teach the child the importance of a communication exchange since many do not spontaneously initiate simple exchanges such as pointing at a desired object. Modelling and picture prompts often work well for all SEN students. Furthermore, students with SEN often display limited attention to certain aspects of a task. This can have a detrimental effect on learning (Perko and McLaughlin, 2002). Comparing employing semantic annotation approach in education and the current SEN interventions, it shows that semantic annotation can have an extensive impact on SEN learning.

The key themes of the literature review synthesised from Table 2.4 utilise the semantic web in education (Cristea, 2004; Aroyo and Dicheva, 2004; Begam, M. Farida; Ganapathy, Gopinath, 2016), utilise semantic annotation in the education process

(Yang, Chen and Shao, 2004; Azouaou et al., 2004; Sylvain et al., 2004; Roy, Sarkar, Ghose, 2010; Hassanzadeh and Keyvanpour, 2011; Weal et al., 2012; Anish, 2013; Oriche, Chekry and Khaldi, 2013; Nithya, Saravanan, 2013; Nithya, Saravanan, 2014; Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas, 2017), and SEN educational requirements for effective learning (Department for children, schools and families, 2007).

From the previous studies, there is no evidence of using semantic annotation presented in different forms to enhance those with SEN, which will be the focus of this research.

Date	Authors	Title	Key Issues	Contribution
2004	Cristea	What can the Semantic Web do for Adaptive Educational Hypermedia?	Adaptive hypermedia.	A conversion method from adaptive hypermedia to the Semantic Web.
2004	Aroyo and Dicheva	The New Challenges for E-Learning: The Educational Semantic Web.	Interoperability among various educational systems, automated, structured and unified authoring support semantic conceptualization and ontologies.	A realistic approach towards the Educational Semantic Web.
2004	Yang, Chen and Shao	Ontology Enabled Annotation and Knowledge Management for Collaborative Learning in the Virtual Learning Community.	Virtual learning communities personalized annotation semantic content retrieval.	Two metadata models, content model and annotation.
2004	Azouaou et al.	Semantic Annotation Tools for Learning Material.	Providing the specification for semantic annotation tools for e-learning.	Two prototypes are developed, and evaluate to annotate learning material.
2005	Sylvain et al.	Semi-automated Semantic Annotation of Learning Resources by Identifying Layout Features.	Some weaknesses of the existing standard models as they require far too much effort and may not even be effectively put in practice by a normal teacher.	Methodology for semi automatically extracting annotations from existing pedagogical documents.
2007	Department for children, schools and families	Designing for disabled children and children with special educational needs.	Children or young people with SEN and disabilities with different teaching requirements.	Manual teaching methods and computerised teaching methods.
2010	Roy, Sarkar, Ghose	A Comparative Study of Learning Object Metadata, Learning Material Repositories, Metadata Annotation and an Automatic Metadata Annotation Tool.	It addresses the need of metadata annotation for efficient retrieval of learning materials from learning object sources.	An automatic annotation tool has been developed for semantic tagging of learning materials.
2011	Hassanzadeh and Keyvanpour	Machine Learning Based Analytical Framework for Semantic Annotation Requirements.	Many obstacles against semantic annotation, such as multilinguality, scalability, and issues related to diversity and inconsistency in content of different Web pages. Automating annotation process is one of the significant challenges in this domain.	Present an inclusive layered classification of semantic annotation challenges. Investigate related researche for better understanding and to reach a framework that can map machine learning techniques into the semantic annotation challenges.

2012	Weal et al.	Semantic Annotation of Ubiquitous Learning Environments.	The use of semantic annotation in the recording and subsequent understanding of simulation learning environments.	Provide novel mechanisms for both student feedback and increased understanding of the learning environment with different annotation methods.
2013	Anish	Skills Based Learning Environments: Semantic Annotation with Mapping Method.	Evaluate the use of semantic annotation as part of a skills-based learning environment to better understand how students learn.	Simulations are used to promote the acquisition of practical skills as well as decision making, team working, communication, and problem solving.
2013	Oriche, Chekry and Khaldi	Intelligent Agents for the Semantic Annotation of Educational Resources-e-Learning.	The Semantic Web can be treated as a suitable platform for implementing an e-learning system with the use of metadata.	A semantic annotation system based on three intelligent agents to manage semantic annotations educational resources and these annotations are guided by domain ontology.
2014	Nithya, Saravanan	Semantic Annotation and Search for Educational Resources Supporting Distance Learning.	Explore, share, reuse, and link multimedia educational resources for better e-learning experiences/ distance learning environments.	Adopting linked data technology to introduce a video annotation and browser platform with two online tools.
2016	Begam, M. Farida; Ganapathy, Gopinath	Personalized learning management system using semantic web based learning style detection.	An approach to detect learning styles of the learner automatically based on learner's interaction, interests and behavior that are captured as ontologies and suggests the learning style of the learner.	Consider Felder Silverman Learning style model. The approach is modeled in Protégé and the learning style obtained as outcome can be used for sequencing the e-learning services.
2017	Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas	The use of Video annotation tools in teacher training	Video annotation in teacher traning; reflective teaching; teacher education and the effect of ICT on teacher training	Review different papers of national and international databases. Compare and contrast studies of video annotation tools over time and articles indexed in databases.

Table 2.4: Researches Contributed in the Education Field

2.6 Literature Findings and Research Direction

In this chapter, the literature review reveals that ICT technologies have an impact on teaching SEN students. There is an increasing interest in utilizing Semantic Web in education in numerous ways. In the light of the previous discussion, teaching SEN students with current teaching methods is a difficult task that requires a huge effort from staff to achieve students' full potential. Resources are expensive and sometime difficult to satisfy the individual needs.

Children with SEN in mainstream schools tend to be taught with their peers in groups of up to 30 with one teacher, depending on the child's age, needs and ability. There may also be a small group and one-to-one work with support staff (Department for Children, Schools and Families, 2007). Meanwhile, group numbers per teacher for children in special classes are based on severity of their needs. For example, one teacher is allocated to between 8 and 15 children with moderate needs, between 6 and 8 children for with severe to profound needs, and between 4 and 6 children with profound needs (Department for Children, Schools and Families, 2007). These numbers put a lot of demand on teaching staff and the SEN final learning achievements. This shows that classes are either big with a limited number of staff or small groups which require more members of staff. Moreover, at regular mainstream schools, the critics of inclusion argued that it does not work in practice and one school cannot meet the needs of all children. For example, MacBeath et al. (2006) debated that many young people with SEN be effectively excluded within a mainstream setting. In the mainstream setting, a teaching style that focuses on the whole class is necessitated, which enforces strict discipline and little opportunity for individual attention (Read, 2007). This review illustrates that there is a need to clarify and address the demands in teaching SEN students and the demand requested from teaching staff. The appropriate techniques required to meet those demands also need to be investigated. The literature illustrates the need for semantic annotation for teaching SEN students and supporting the teaching staff. There is no methodological approach that exists in the literature using semantic annotation in: (1) Developing new teaching methods/resources to enhance SEN learning; (2) Developing new approaches for improving SEN class management (students' engagement and behaviour); (3) Developing new methods for supporting SEN staff with their preparation and routine work.

From the previous points comes the urgent need for adding semantic metadata to SEN teaching material such that they are understandable for humans and machines. Though there exists a wide range of sophisticated, even professional, annotation tools as depicted in Table 2.3. After reviewing the set of tool features and by identifying the most applicable tools to be tested within the SEN domain, two tools should be selected and compared. The study first focuses on the implication of using semantic annotation in enhancing the SEN student learning experience. Similarly, its capacity to reduce the work required from the teaching staff by reducing preparation time and behavioural problems. Table 2.5 presents the gaps tackled in this research. This research aims to address the following gaps by proposing a methodology based on the use of semantic annotation to enhance SEN students learning and support their teaching staff.

Gap	Gap Description	Literature	Proposed plan
1	Current teaching methods are manual or computerised with purchased equipment or applications.	(Zane, 2016; ATL, 2013; Millar, 2010; Glazzard et al., 2010)	To reduce/replace the current manual teaching methods with new SEN tool.
2	There is no evidence that semantic annotations were used in teaching SEN students.	Davedzic (2004, 2016) states that the Semantic Web is used in education.	To develop and use semantic annotation for the new approach of enhancing teaching SEN.
3	The preparation of the current teaching methods is expensive, time consuming and require a lot of effort to prepare (search for materials, design and create materials, easy to make errors and time consuming).	(Department for Education and Morgan, 2016; Millar, 2010).	To develop a SEN platform that is available for the teaching staff either online or at local server.
4	Current SEN teaching methods could be ready-to-use applications, internet or designed by office applications.	(Florian, 2004)	Proposed platform save staff time, effort and is cost effective by utilising semantic annotations in different forms.
5	The teaching staff struggle with dealing with various SEN types and needs.	(MacBeath et al., 2006)	To develop SEN platform that can reduce behaviour problems, increase motivation and concentration of SEN students.
6	Involving SEN students in mainstream school is difficult.	(Becta, 2003)	To develop a SEN platform that supports inclusive education to involve all students without discrimination because of specific learning needs.

Table 2.5: An Overall Summary Table of the Research Gaps

Chapter 3: Hypothetical Foundation and Potential Methodology

'Failure is not falling down but refusing to get up.' Chinese proverb

3.1 Introduction

This chapter investigates and presents Design Science Research (DSR) as the chosen methodology with which to execute this research. It will detail the phases, techniques and philosophical background behind this method. Design Research employs a set of techniques to implement research in Information Systems. Normally, this entails analysing the use and potential of a designed artefact. The chapter also presents the justification for choosing Design Research as the framework to guide the research execution.

This chapter is structured as follows: Section 3.2 highlights the different research approaches employed in information systems (IS) research, argues for the importance of design science within information systems, and presents a discussion of the background of DSR, its philosophies, processes and evaluation methods. Section 3.3 describes the employment of DSR in the context of this research and explains the individual iterations within the development stage and evaluation of the proposed approach. Section 3.4 explains the ethical considerations for this research. Finally, a summary of the chapter is presented in Section 3.5.

3.2 Design Science Research Background

Research in information systems (IS) has attracted increasing attention in the last decade because IS can improve the effectiveness and capabilities of organisations (Nunamaker et al., 1991). The nature of IS research is complex because the IS field is multidisciplinary as IS has strong links with other domains, such as medicine, engineering and social science (Baskerville and Myers, 2002). This variety and richness in the IS field has resulted in having different IS research methods (Land, 1992). Design Science Research is one of the approaches to research in Information Systems that has emerged in the last decade. DSR is primarily a problem-solving paradigm where a set of analytical techniques and perspectives assist in performing research in the area of information systems and computing (Hevner et al., 2004). It can also be defined as ‘learning through building – artefact construction’. DSR involves the design of artefacts characterised as novel, innovative and purposeful, and the analysis of the performance of such creations, in order to understand and enhance the behaviour of certain aspects in information systems (Vaishnavi and Kuechler, 2009). Hevner et al. (2004) regard design research as an innovative means of solving a problem, while Edelson (2002) and Winter (2008) distinguish design research by the generality of the proposed solution in that it can be applied to a wider class of situations, thereby leading to design science. Simon (1996) makes a valid differentiation between behavioural science and design science by unfolding the science of the artificial; Simon introduces the notion of an artefact, viewed as a link between the inner and outer environment in the search for a solution that fulfils the desired goal in seeking a satisfactory design, rather than an optimal one. Design Science Research is a learning process through which the underlying artefact development process is observed (Hevner et al. 2004; Hannes and Stefan, 2014; Vaishnavi and Kuechler, 2004).

Design Science Research, as presented by March and Smith (1995), signified the beginning of a new research era. This new era enabled research to achieve both relevance and effectiveness by combining research output (product) and research processing (activities) from behavioural and design science in a two-dimensional framework, as presented in Figure 3.1. The four research activities drawn from design science and natural science are: Build, Evaluate, Justify and Theorise. These four processes are applied in IS research to produce the following types of artefacts: constructs, models, methods and instantiations. These artefacts are employed to ensure the utility and efficiency of the produced IS. Design research would appear to achieve an optimal solution to the design problem through iterative knowledge refinement.

		Activities			
		Design		Natural Science	
		Build	Evaluate	Theories	Justify
Artefacts Research Output	Constructs				
	Models				
	Methods				
	Instantiations				

Figure 3.1: A Research Framework (March and Smith, 1995)

Hevner et al. (2004) provide a concise IS research framework and present methodological guidelines for identifying, executing and evaluating IS research. Build and evaluate are considered iterative processes through which both method and product are assessed carefully by the researcher and used to assess and refine the developed product. This evaluative process typically applies measures established in a literature review to assess the utility, efficacy and quality of the designed artefact.

Categorising design artefacts using March and Smith's (1995) research outputs classification can help in identifying an appropriate procedure to build, evaluate, theorise and justify the research. The four types of research artefacts are described below.

• **Constructs**: Constructs are sets of concepts or vocabulary that form specialised knowledge within a domain; they are used to define problems and solutions (Hevner et al., 2004).

• **Models**: Models use constructs to describe a real-world situation of the design problem and its solution space (Hevner et al., 2004); models can be used to express relationships between constructs (March and Smith, 1995).

• **Methods**: Methods are a set of steps that define the solution space. They provide guidance on how to solve problems using the constructs and the models. Methods can be thought of as methodological tools that are created by design science and applied by natural scientists (March and Smith, 1995).

• **Instantiations**: Instantiations are the implementation of constructs, models or methods within a working system. They prove the feasibility and effectiveness of the models, methods and constructs, allowing actual evaluation (March and Smith, 1995). Instantiation can be regarded as playing an important role in enabling researchers to learn about the working artefact in a real-world scenario. As Newell and Simon (1976) explain, the significance of instantiations is in providing a better understanding of the problem domain and consequently offering better solutions.

The second dimension of the framework concerns research activities. March and Smith (1995) identify build and evaluate as the two main activities in design science.

• **Build** refers to the construction of constructs, models, methods and artefacts.

• **Evaluate** refers to the development of criteria and the assessment of the output's performance against those criteria.

• **Theorise** refers to the construction of theories that explain how or why something happens. In the case of IT and IS research, this is often an explanation of how or why an artefact works within its environment.

• **Justify** refers to theory proving and requires the gathering of scientific evidence that supports or refutes the theory.

According to Owen (1998) and Takeda et al. (1990), knowledge can be generated and accumulated through a process that iterates through knowledge using and knowledge building activities. Consequently, design is considered as a process; the steps involved in the design process are clearly identified by Vaishnavi and Kuechler (2004). Design can be employed as a research that generates knowledge. A number of studies attempt to link theories and design to justify design as a research approach leading to theories (Brown, 1992; Kelly and Lesh, 2000), while others attempt to put emphasis on the learning aspect of Design Research, and identify types of learning that can evolve when a researcher engages in the design process, as demonstrated by Edelson (2002).

A general DSR methodology that incorporates five phases of design and motivates an iterative design cycle in which learning is a key attribute is proposed by Vaishnavi and Kuechler (2004), adopted from Takeda, Veerkamp and Yoshikawa (1990). Problem awareness is the initial phase in the DSR model, followed by suggestions for a problem solution which are abductively drawn from the literature review. The third phase is artefact development to provide a solution, a tentative design and to produce a proposal to implement an artefact. The implementation results are then evaluated according to a functional specification during the evaluation phase. This phase tests the utility of the artefact in the problem domain. Conclusion indicates the end of a research cycle of a specific design science research which involves highlighting the results of the DSR, adding knowledge to the solution space or feeding back to consequent cycles (Vaishnavi and Kuechler, 2004).

Nunamaker, Chen and Purdin, (1990) agree that system development (artefact construction) is considered as a research methodology that can lead to an improved, and more effective design when applied in conjunction with other research methodologies, whilst at the same time making a rigorous contribution to knowledge. In accordance with utility and truth as two important aims of Design Research and behavioural science respectively, Design Science Research is proposed by March and Smith (1995) and Hevner et al. (2004) as a research framework, where IS research can occur by integrating two complementary disciplines. The first of these is behavioural science, where research is more focused on theorise and justify the process, and the second is DSR, where the research is more focused on the build and evaluate the process (Purao 2002).

3.3 Design as an IS Research Methodology

Design research frameworks attempt to provide the Information System (IS) community with a Design Science Research (DSR) methodology (Hevner et al., 2004; March and Smith, 1995; Nunamaker and Chen, 1990). Within these, a common process is an iterative design cycle employed as a problem-solving process, where valid IS research is achieved through the building and evaluation of purposefully designed artefacts. Importantly, research in IS resembles all other research. For example, Blake (1978, p.31) defines research as 'systematic, intensive study directed toward fuller scientific knowledge of the subject studied'. IS research is considered a multi-inter-related disciplinary field, comprising social and natural sciences, management and engineering, and bound by an overlap of research methods, in which continued improvement is required to meet the complex dual nature of the IS field (Purao, 2002; Nunamaker and Chen, 1990). In the discipline of IS, DSR seeks to improve significantly those aspects related to the analysis, design, implementation, management and use of information systems through the creation of useful artefacts (Hevner et al., 2004).

Typical research in information technology (IT) is commonly categorised as either knowledge using action, where research aims to improve IT performance, or knowledge producing action, where research aims to understand the nature of IT (March and Smith, 1995). In both cases, IS research takes place as a juncture connecting people, organisations and technology; therefore, IS clearly incorporates IT research. Simon (1996) makes a clear distinction between natural science and science of the artificial (design science); the first is concerned with naturally occurring phenomena, whilst the second relates to artificial human-made artefacts. In making this distinction, the IS community has come to realise and justify the need for design as a research discipline that combines the two (March and Smith, 1995a, Winter, 2008; Hevner et al., 2004; Edelson, 2002; Nunamaker and Chen, 1990).

In design science research, truth and utility are considered to be vital elements, gained through an implicit cycle between design science and behavioural science, where truth is provided by IS theories and utility is provided by IS artefacts (Hevner et al., 2004).

The design cycle is executed in an incremental process that can be initiated by simple conceptualization providing the necessary learning that feeds into consequent iterations, where the final iteration results in an improved product that satisfies the problem requirements and constraints. An earlier Design Science Research framework presented by Nunamaker, Chen and Purdin (1990/91) that connects aspects of design and design science. In their framework, Nunamaker, Chen and Purdin (1990/91) assign system development a central role in the research life cycle, again showing an integrated approach that includes design science as a core component in an Information Systems methodological research framework.

Hevner et al. (2004) on the other hand propose a descriptive Design Science Research framework as illustrated in Figure 3-2 that satisfies both natural science and design science. Research rigour can be achieved by applying knowledge (theories) effectively from the knowledge base in order to develop and build an IS artefact. Moreover, relevance can be accomplished by assessing whether the artefact satisfies research needs. The justify step evaluate process is used to assess the artefact’s applicability in the appropriate environment (Hevner et al., 2004).

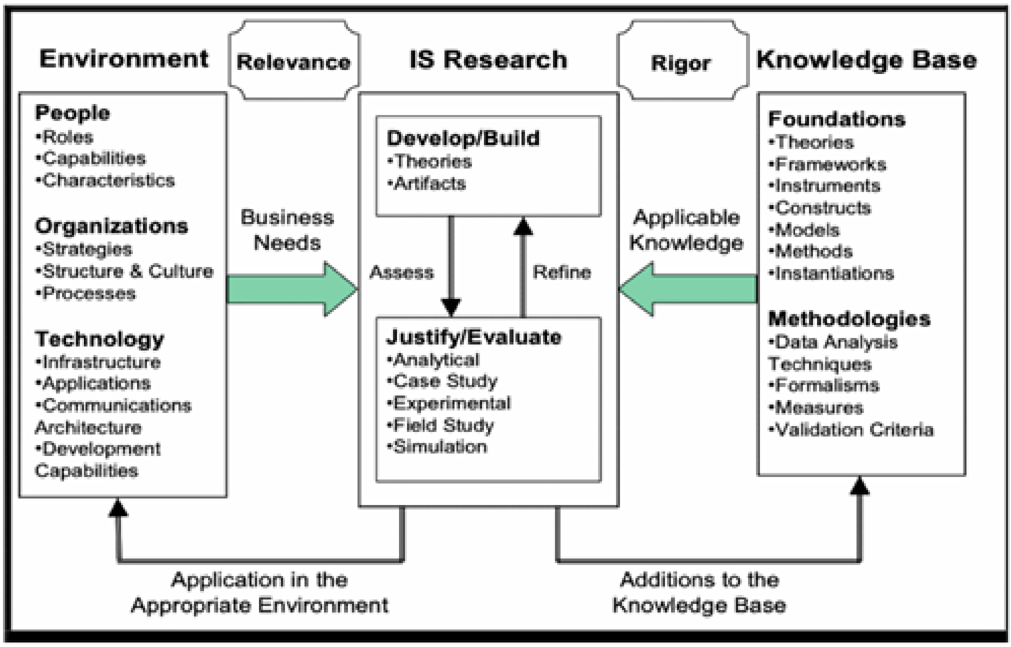


Figure 3.2: Information System Research Framework (Hevner et al., 2004)

In Hevner et al. (2004) a concise IS research framework is presented and used to induce Design Research methodological guidelines that can be followed to identify, execute and evaluate IS research. The focus of this methodology is on developing and evaluating IT artefacts that are described as new, innovative and novel, for solving problems or achieving improvements (Hevner et al., 2004; Ivari and Venable, 2009). The incremental iterative artefact should potentially offer better solutions to organisations and individuals that can enhance existing practices (Vaishnavi and Kuechler, 2004). The problem-solving paradigm of DSR is based on human creativity, the effort put into the design and building of artefacts (Hevner and Chatterjee, 2010; Vaishnavi and Kuechler, 2004; Nunamaker et al., 1990/1991; Vaishnavi and Kuechler, 2004; Gregor and Jones, 2007). Also, DSR is characterised by the iterative reconstruction of artefacts, and assumes that knowledge emerges during the iteration effort (Vaishnavi and Kuechler, 2004). Clearly, the design process in DSR can be seen as a learning process, whereby understanding is enhanced in each iteration, which in turn helps to improve the artefacts 'quality'. The evaluation as part of an iterative process in the DSR typically applies measures from the knowledge base to assess the utility, efficacy and quality of the designed artefact. Hevner et al. (2004) suggested a set of evaluation methods that can be used to evaluate the designed artefact discussed in the next section.

3.4 Design Research Evaluation

Evaluating a Design Science Research artefact is a vital phase; its importance resides in the need to determine artefact performance and measure progress according to well defined metrics (March and Smith, 1995). Assessing the progress made in the problem space when the artefact is built to perform a specific task demonstrates its utility, and therefore, validates the research. On the other hand, evaluation plays a fundamental role in iterative research (design science) where knowledge generated from the evaluation phase can be fed back into consequent iterations. Hence, developing appropriate evaluation metrics to assess artefact performance for proving the evaluation criteria (March and Smith, 1995) is critical. Here the evaluation criteria of the so called quality attribute will be identified based on artefact type, as proposed by March and Smith (1995), and is summarised in Table 3.1. Generally, evaluation is concerned with answering the important question ‘How well does the artefact work?’ (March and Smith, 1995). This can be answered by applying a suitable evaluation metric or measure from the knowledge base, thereby proving the appropriate evaluation criteria. For example, a search algorithm instantiation in the information extraction field can be evaluated by a mathematical metric such as precision and recall (Hevner et al., 2004). Therefore, these metrics can be used to prove the efficiency and effectiveness of the algorithm.

Artefact Type	Brief Description	Evaluation Criteria
Constructs	The conceptual vocabulary and symbols describing a problem within a domain.	Completeness, simplicity, elegance, understandability and ease of use.
Models	A set of propositions or statements expressing relationships between the underlying designs constructs; they represent situations as problem and solution statements.	Fidelity with real-world phenomena, completeness, level of detail, robustness and internal consistency.
Methods	A set of steps used to perform a task – how-to knowledge; method can be tied to particular models; they may not be articulated explicitly but represent tasks and results.	Operationality (ability of others to efficiently use the method), efficiency, generality and ease of use.
Instantiations	The operationalisation of constructs, models and methods; they are the realisation of the artefact in its environment to ensure its feasibility; e.g. (prototypes or the implemented artefacts).	Efficiency, effectiveness and impact on an environment and its users.

Table 3.1: Evaluation Criteria with Artefact Types (March and Smith, 1995; Hevner et al., 2004)

Once the evaluation metrics and criteria are identified, an empirical study is applied (March and Smith, 1995), where an appropriate evaluation method is chosen. Hevner et al. (2004) emphasise that the selection of the evaluation method should be carefully considered, and, when matched with the suitable artefact and evaluation metric, evaluation methodologies are typically drawn from the knowledge base. An inclusive set of evaluation methodologies are summarised in Table 3.2, adopted from Hevner et al. (2004). The classifications represent the most common evaluation methods from which a suitable method can be applied based on the type of artefact and the evaluation metrics used.

Guideline	Description
Observational	**Case study**: Study artefact in-depth in business environment.
	Field study: Monitor use of artefact in multiple projects.
Analytical	**Static analysis**: Examine structure of artefact for static qualities (e.g. complexity).
	Architecture analysis: Study fit of artefact for technical IS architecture.
	Optimisation: Demonstrate inherent optimal properties of artefact or provide optimality bounds on artefact behaviour.
	Dynamic analysis: Study artefact in use for dynamic qualities (e.g. performance).
Experimental	**Controlled experiment**: Study artefact in controlled environment for qualities (e.g. usability).
	Simulation: Execute artefact with artificial data.
Testing	**Functional testing**: Execute artefact interfaces to discover failures and identify defects.
	Structural testing: Perform coverage testing of metric/s (e.g. execution paths) in the artefact implementation.
Descriptive	**Informed argument**: Use information from knowledge base to build a convincing argument for the artefact's utility.
	Scenarios: Construct detailed scenarios around the artefact to demonstrate its utility.

Table 3.2: Design Evaluation Methods (Hevner et al., 2004)

3.5 Applying Design Research

The research presented in this thesis begins with the development of a conceptual framework for the SEN Teaching domain to develop SEN Development Media (SDM). This research presents an actionable design process for annotated SEN media creation – operationalised as a blueprint. To meet the research aim, DSR will be adopted from Vaishnavi and Kuechler (2004) as an overall research methodology alongside March and Smith's (1995) research product classification. Research products will be identified in the form of constructs, models, methods and instantiations. The Design Research methodology employed for developing the research artefacts is an iterative design cycle (build and evaluate). The main design artefact is a methodological SDM framework, an iterative process involving the five design process steps: awareness, suggestion, development, evaluation and conclusion, as elaborated in Figure 3.3.

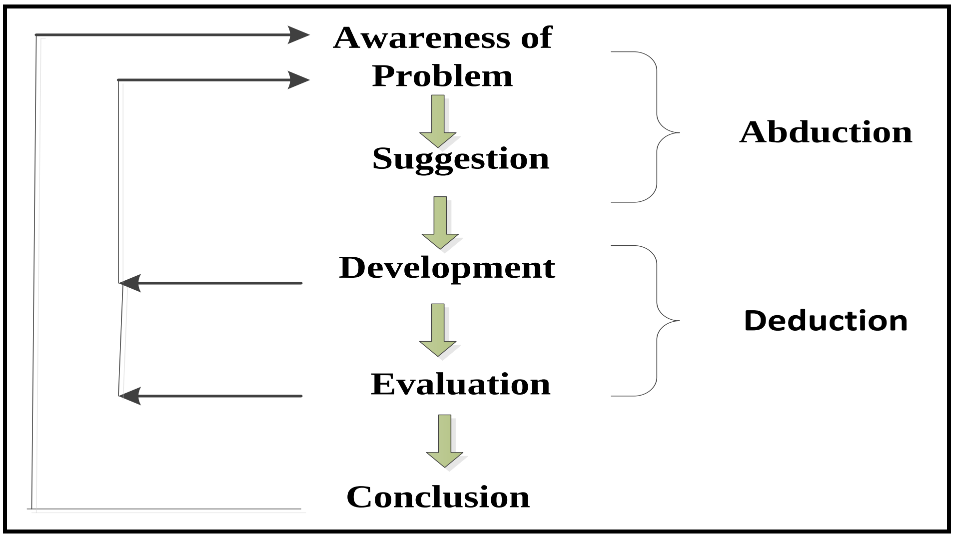


Figure 3.3: Design Science Reseasrch Cycle (Vashnavi and Kuechler, 2004)

Hevner et al. (2004) propose practice rules in the form of seven guidelines for conducting DSR in information systems. These guidelines establish real, rigorous and relevant Design Research. The most important of these is that the research must produce an artefact created to address a problem, as outlined in Table 3.3 (Hevner et al.; Peffers et al., 2008; De Villiers, 2012).

Peffers et al. (2007) suggest that an established DSR process model would encourage more IS research using the DS paradigm. Such a model, combined with prior DSR, would provide a complete DSR methodology (DSRM) and a set of activities. Using the extant literature on design research, Peffers et al. integrate the principles into a comprehensive methodology, a DSRM process comprising six activities in a defined sequence. First, identify the problem, capturing its complexity. Second, define objectives for a solution (quantitative or qualitative); what it should realistically do.

Third, design and develop the artefact (a construct, model, method or instantiation). There must be a research component in the design. Fourth, demonstrate use of the artefact to solve an instance of the problem such as an experiment, case study or any other convenient method. Fifth, evaluate by using metrics and analysis to observe and measure to what extent the artefact solves the problem. If necessary, return to the third step to improve the artefact. Finally, communicate by publishing in scholarly journals and professional vehicles.

Guidelines	Description
1: Design as an Artefact	An innovative, viable artefact must be designed and produced to address an identified problem.
2: Problem Relevance	The solution must have utility in addressing a relevant problem, though it need not be fully operational.
3: Design Evaluation	The utility, quality, and efficacy of the design artefact must be rigorously evaluated.
4: Research Contributions	Effective DSR must provide clear, new, innovative, and verifiable contributions in the areas of the design artefacts, design foundations, and/or design methodologies.
5: Research Rigour	DSR relies upon the application of rigorous methods in both the construction and evaluation of the design artefacts. Rigour is necessary, but should not reduce relevance. Human aspects should be addressed.
6: Design as a Search Process	Iterations and cycles of generate-and-test are appropriate design methods. The search for an effective artefact requires utilising available means to reach planned objectives.
7: Communication of the Research	DSR must be presented effectively both to end users and to professional or technological audiences. Users are interested in the artefact's impact, novelty and effectiveness, while technologists are concerned with construction details.

Table 3.3: Design Research Guidelines

DSR processes follow a systematic approach, structured in several phases. Vaishnavi and Kuechler (2004) categorise the DSR processes into five phases, starting with awareness of problem, followed by suggestion, development and finally evaluation, which in turn leads to a conclusion as depicted in Figure 3.4. A distinctive feature of

DSR is its iterative nature, which implies that the 'build–evaluate' process can be repeated until satisfactory artefacts are obtained (Markus et al., 2002). Simon (1996) and Hevner (2004) described DSR as an incremental process so that the design process of a complex artefact can be broken down into semi-independent components to make the desired artefact. In incremental DSR, each artefact, part of the artefact or set of artefacts are designed during a DSR phase. It is worth mentioning that incremental design is necessarily associated with incremental learning, since the understanding of the design process is improved as the design grows and more components of the final artefact are developed and evaluated.

Problem Awareness will be based on conducting a comprehensive review and analysis of the related literature. This involves reviewing the literature and analysing existing special needs learning resources and ontology techniques, in addition to recognising the importance of semantic annotation in education. It also incorporates finding suitable semantic annotation, ontology techniques and the special needs learning styles and requirements which are appropriate for developing a SEN Development Media (SDM) framework (as described in Chapter 2). Problem awareness is shown by reviewing different special needs issues, their special learning requirements, current SEN teaching methods and the challenges in teaching special needs students. Based on this awareness, the requirements of the teaching staff need to be specified. To select the semantic annotation tools, existing semantic annotation approaches are compared and the possibility of using them in teaching within the SEN domain is assessed. Finally, the gaps and inconsistencies in the literature are identified and directions for future research are suggested.

Suggestion involves introducing a tentative idea of how the problem might be solved by suggesting appropriate semantic annotation techniques (Dawod and David, 2011). This step forms Iteration one, which involves selecting the appropriate tools that are appropriate for the pilot study in iteration two, which will be conducted in a real SEN environment. As new knowledge is gained during the development and evaluation of the developed method, new suggestions from the build and evaluate cycles are used to initiate subsequent iterations.

Development is carried out by building the research artefact as a SEN Teaching Platform (SENTP). The framework consists of phases and steps that adopt the semantic annotation techniques within teaching material to improve the students understanding, behaviour and increase their engagement. In addition, the framework can support the teaching staff with their routine work. The SEN Development Media (SDM) is aimed to design a SENTP blueprint that articulates the results.

Evaluation is performed through an evaluation strategy that measures the validity and effectiveness of the research based on the potential performance improvements when using the developed framework over the existing domain. Design Science Research evaluation criteria are used to examine the efficiency and generality of the framework. Computerisation of the process of preparing the teaching resources for special needs using an appropriate semantic annotation tool resulted in development of a tool that served as an instantiation of SENTP. Evaluation of the efficiency and effectiveness of the tool developed as an instantiation of SENTP is also performed. Then different forms of the annotation in the SEN framework were evaluated.

Initially, The SENTP is evaluated using an experimental evaluation method. The evaluation is performed to ensure that semantic annotation is capable of supporting the special needs learning and supporting the teaching staff. A set of evaluation criteria developed from the literature review are used for this evaluation. The evaluation task is composed of two different sets of experiments. The sets comprise an experiment conducted using different types on annotation tools and include building ontology techniques in one of them. Then, SENTP is evaluated using qualitative methods to identify problems and strengths. Applying the framework to a real SEN domain resulted in development of adding the concept of teaching staff experience and the employment of semantic annotation to extend the SEN framework.

Conclusion: providing a summary of the research output and identifying the evaluation results and highlighting areas for future improvement. This phase concludes the DSR cycle, which motivates knowledge generation as part of the design problem; new awareness is generated, and suggestions are made during each build and evaluate cycle. Learning form each iteration is used to refine the explanatory hypothesis and feedback into subsequent iterations. Once the artefact has been built and the evaluation is satisfactory, the designer will put together the knowledge acquired throughout the design cycle, providing guidelines for users to use the artefact in their field. In addition to the outcomes of the research study, knowledge acquired during the design cycles can be used by the practitioners as guidelines on how to use the developed artefacts in similar situations.

Applying March and Smith's (1995) Design Science Research product classification to illustrate research contributions leads to identifying the main design artefacts. The activities in this research are executed using an iterative DSR method, consisting of three design iterations.

3.6 Research Iterations

Design Science Research is performed through iterative design cycles, within which one can take either the Iterative Approach or Incremental Approach. Incremental development is a method of software development where the model is designed, implemented and tested incrementally until the product is finished. It involves both development and maintenance. The product is defined as finished when it satisfies the users' requirements. On the other hand, the Iterative Approach is a design methodology based on a cyclic process of prototyping, testing, analyzing, and refining a product or process. Based on the results of testing the most recent iteration of a design, changes and refinements are made. This process is intended to ultimately improve the quality and functionality of a design. It has no set number of steps, rather development is done in cycles. The iterative approach is now becoming common practice because it better fits the natural path of progression in software development. Instead of investing a lot of time and effort chasing the 'perfect design' based on assumptions, the iterative approach is all about creating something that's 'good enough' to start and evolving it to fit the user's needs (Hevner et al., 2004).

This research is implemented as an iterative approach where each iteration is used to extend and refine the design problem (SENTP):

1. Identify SEN Development Media (SDM) Framework constructs and choose a domain that uses SENTP actively to evaluate the rest of the study. Develop the core ontology of SENTP which will be utilised with semantic annotation tools and select the suitable tools for this research.
2. The framework is refined and extended by developing techniques to identify SEN Development Media (SDM) Framework constructs with the existing teaching methods. Also, the developed structure the SENTP is generalised and validated.
3. The framework is refined by adopting Cognitive Load theory to enhance the GUI of the SENTP. Also, the developed structure of the SENTP is generalized and validated within a wider data set. Furthermore, design and create a SENTP blueprint to generalise the concept for different types of learning material, different student issues and needs. Furthermore, the SENTP ontology is refined by by generalising the developed ontology to be adapted for different learning content, and range of styles and age.

Three design iterations are used to deliver the final artefact, as illustrated in Figure 3.4. In each iteration, the artefact refinement process comprises a mini design research cycle of build and evaluate, following Vashnavi and Kuechler's (2004) design cycle steps.

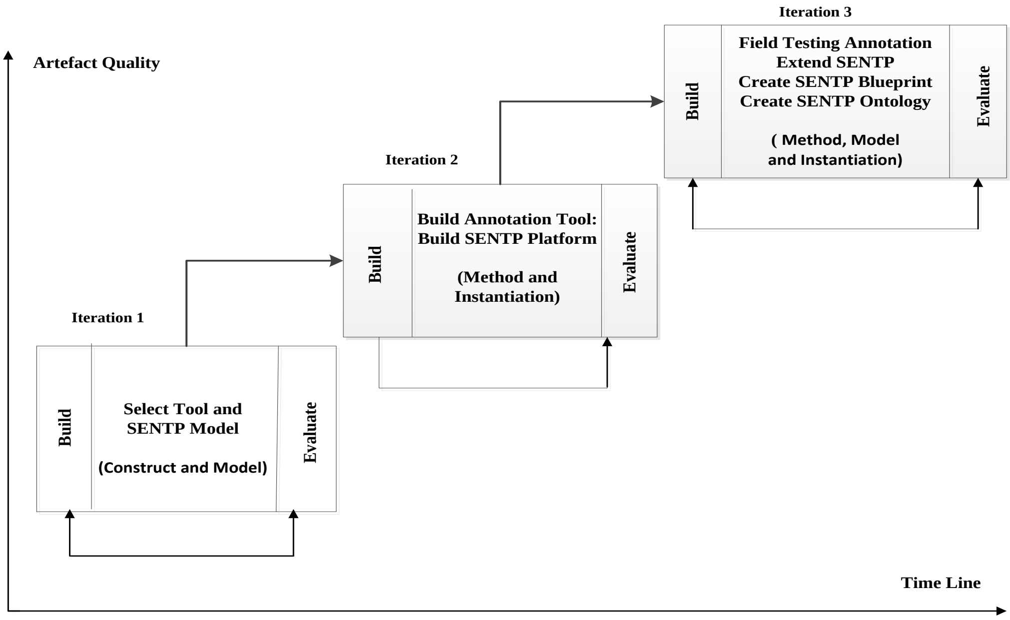


Figure 3.4: Research Iterations

Importantly, Design Science Research motivates knowledge generation as part of the design problem; new awareness is generated and suggestions are made during each build and evaluate cycle. The learning outcomes form the iterations is used to refine the explanatory hypothesis and feedback into subsequent iterations.

The main DSR outcome is the development of a methodological framework (SDM), where a framework starts with a survey about the project scope to achieve a preliminary awareness of the challenges related to the problem domain, identify hypotheses to be tested and evaluated using information artefacts (Rocha, et al., 2017). Methodology is defined by Checkland (1999) as *'A set of principles of method, which in any particular situation has to be reduced to a method uniquely suited to that particular situation'*. SDM incorporates aspects of both a methodology and a framework.

3.6.1 Iteration 1: Construct and Model

This iteration aims at analysing, understanding and testing the applicability of existing ontology techniques, more specifically the suitability of utilising semantic annotations in different forms in teaching of the SEN domain. This is achieved by comparing and testing different semantic web techniques such as Semantic Web languages, ontology editors and semantic annotation tools. Appropriate tools were selected; implement and compare two platforms based on two annotation tools to select one to continue in the next iteration. The results were evaluated based on the literature review. The output of this iteration is a set of constructs, a model and instantiation that identify the appropriate semantic annotation techniques to conduct the pilot study.

Reviewing different special needs issues needs from the literature in Chapter 2 to identify and synthesise a new way of describing the language as constructs. SENTP model is created by designing SEN ontology based on selected teaching material as well as the SENTP model which included different tools to compare. Moreover, the process of semantic annotation is used as a method in this iteration. Finally, synthesise SENTP webpage from an initial SEN Development Media (SDM) framework which consist of a semantic annotation tool and an ontology building method. A prototype application is created as an instantiation of SENTP as illustrated in Figure 3.5.

The method is evaluated for its efficiency, generality, completeness, simplicity, consistency, effectiveness and quality of result by applying it using the instantiated application on an educational website. This is a simulated example designed and implemented by the researcher and based on the literature review. The content is selected from the national curriculum according to students' needs (age and issue). The evaluation is based on a set of evaluation critera from literature review. Figure 3.5 shows the architecture of the SDM framework.

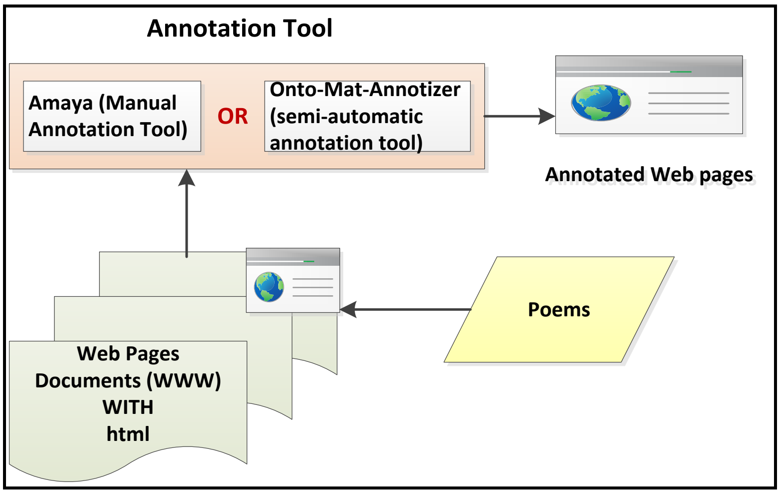


Figure 3.5: Architecture of the SDM Framework

3.6.2 Iteration 2: Extend the SENTP: Build Annotation Tool

This iteration aims to synthesise and analyse concepts, empirical findings and the gaps in literature from testing in a real SEN domain. It tests applicability of using semantic annotation techniques which are selected in iteration one to enhance special needs education within a real SEN domain. The pilot study is conducted to understand the current teaching methods' limitations and requirements at schools caring for SEN students. In addition, this iteration populates and uses the SEN teaching model instantiated in Iteration 1, using the evaluation feedback to build and refine the SEN Teaching Platform (SENTP) for school. The SENTP is extended by adding a new way of describing the language using the effective existing methods used to teach SEN students. The evaluative framework for this iteration is aimed at evaluating the efficiency and operationality of semantic annotation process.

Therefore, to discover more about the teaching staff experience and the SEN students' attitudes in school as well as evaluating the SENTP application, a set of interviews will be conducted with the teaching experts. By utilising the interview data, this iteration seeks to enrich the literature review by investigating: (1), the existing teaching methods; (2) main issues and concerns in teaching SEN students; (3) Limitations in current teaching methods and aims suggestions from the staff for any future approach (4) the main factors required to teaching in special needs environment (5) teaching poetry for SEN students. The use of semantic annotations in teaching SEN students will be tested to see its applicability to support the students and the staff in a real SEN domain. A set of interviews with the teaching staff will be conducted. All the interviews will be recorded and last approximately one hour. When, analysing the collected data, a thematic coding process will be used. All the themes will captured something important data related to the research question, and represent some level of pattered response or meaning within the data set (Braun and Clarke, 2006).

Interviews will be transcribed, verified and analysed. The interview data will be analysed thematically using Nvivo. NVivo10 will be used for the purposes of organising, categorising and searching textual, recorded data. NVivo10 was found to be comprehensive in its functionality, operationally stable, easy to use, error free, and had a significant number of standard reports and export facilities. It has been proved ideal for manipulating and analysing the data gathered in this exercise. Interview notes will initially be typed up in Microsoft Word. NVivo10 supports different formats so all notes and documentation will be imported into the system for analysis. Each imported file will be reviewed and every significant sentence, phrase or word will be allocated a code. These initial codes will be then reviewed and a process of consolidation will merge codes that have, or appear to have, the same meaning.

It also equates to the circumscription feedback loop of the Design Research stages defined by March and Smith (1995). The outputs of this iteration comprise the second version of the SENTP methodology. The evaluative framework for this iteration is aimed at evaluating the efficiency and operationality of the method (SENTP), by applying the instantiated application on real SEN environment. The evaluation is based on the evaluation criteria put forward by March and Smith (1995), defined earlier in Table 3.4.

3.6.3 Iteration 3: Field-Testing Annotation

The aim in this iteration is towards populates and uses the SENTP model instantiated in Iterations one and two. Additionally, The SENTP blueprint synthesis in detail the pragmatics of deployments and the interactions between stakeholders. Furthermore, the SENTP ontology generalise the concept of utilising semantic annotation to creat media element for any SEN teaching content.

This iteration uses the learning (formed by evaluate, theorize and justify activities), shaped by Iteration two, to suggest improvement of the models. This leads to developing the final products of the research consisting of SDM methodological framework, SENTP model by adapting Cognitive Load Theory (CLT) in the design of SENTP webpage. The feedback from Chapter 5, the teaching staff reviews, shows a number of SEN cognitive load issues that needed to be improved such as developing their memory limit. In addition, the feedback from the teaching staff shows the significance of developing understanding, engagement, behaviour and resource preparation for an effective SEN learning. Hence, SENTP instantiation will be extended to include CLT principles within the SENTP UI. CLT has an extensive impact on developing these factors in comparisons with other learning theories. Hence, CLT was selected to develop the SENTP UI for field testing in wider SEN domain. Measuring significant improvement of the research requires careful evaluation in order to prove efficiency (March and Smith, 1995) and assess the progress made in the problem domain is done by applying the developed products into real Web Services' artefacts. Therefore, to discover more about the teaching staff experience and the SEN students' attitudes in school as well as evaluating the SENTP application in wider data set, a set of interviews will be conducted with the teaching staff experts. By utilising the interview data, this iteration seeks to enrich the previous feedback by investigating: (1) the existing teaching methods; (2) main issues and concerns in teaching SEN students; (3) Limitations in current teaching methods and aims suggestions from the staff for any future approach; (4) the main factors required to teaching in special needs environment; (5) teaching poetry for SEN students; (6) the possibility of reducing/replacing the current teaching methods with SENTP; (7) the effect of SENTP on reducing the students cognitive load; and (8) the possibility of using SENTP for different age ranges and issues. The semi-structured interview questions will be refined according to the feedback obtained from Iteration 2 if required for achievement of the research objectives. The timing for the interviews will be adjusted according to staff availability.

This iteration artefact is evaluated according to the evaluation criteria put forward by March and Smith (1995), defined earlier in Table 3.4, by applying the instantiated application on a real SEN domain. NVivo11 will be used for organising, categorising and analysing the data. Figure 3.6 summarises the SENTP model of the field testing annotation stage, which coordinates the SENTP from Iteration 2 with the idea of using cognitive load theory.

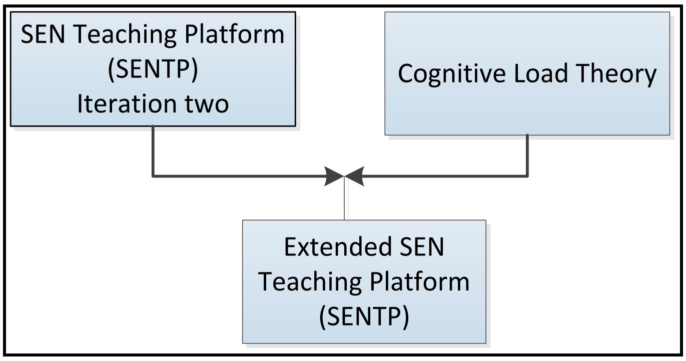


Figure 3.6: SENTP Model (Field Testing Annotation)

All the interviews will be recorded and the collected data will be analysed using a thematic coding process. All the themes will capture something important about the data in relation to the research questions, and represent some level of pattered response or meaning within the data set (Braun and Clarke, 2006). Each of the iterations that follow then derives its requirements from the feedback of the previous iteration. To theorise and justify, as identified by March and Smith (1995), are mainly behavioural science activities, where, theorising the SENTP implies understanding how and why it can be applied in a real SEN domain, and justification of the SENTP implies proving its applicability across different sets of school sectors. The utilisation of different forms of semantic annotation designed in different organisations within the UI platform will be theorised and justified in chapters 5 and 6. Table 3.4 illustrates the research products versus the research processes.

Executing the research in a design research incremental iterative manner enables learning to emerge from the first iteration by applying and testing techniques from the knowledge base on Web Services. Table 3.4 summarises the three design research iterations, illustrating the objectives and output artefacts of each. Research iterations are described in more detail in the following chapters.

Research outputs	Build	Evaluate	Theorise	Justify
Constructs	Review the literature, test the existing approaches and comparisons (Iteration 1) Describe the language (Bigger, Smaller, Video, Image) (Iteration 1) Extend and refine the way to describe the language by adding the existing symbol systems (Makaton, Widgit, PECS), Sound, text and Imag (Iteration 2)	Completeness Simplicity Elegance Ease of use	Explain why and how constructs work by employing them to describe poetry teaching materials (addressed in chapter 2, 4, 5 and 6)	
Models	Symbol Taxonomy SEN ontology model An initial framework SDM (Iteration 1) Extend Framework SDM (Iteration 2) Extend Framework SDM (Iteration 3)	Fidelity. Completeness Level of detail. Robustness Internal Consistency	Adapt theories from the existing SEN discipline Evaluate the use of semantic annotation in education, and employing it in a SEN domain (chapter 4, 5 and 6)	To be demonstrated in chapters 5, 6 and 7
Methods	SLR method (chapter 2) Qualitative methods by arranging interviews with the teaching staff (Iterations 2 and 3) Semantic Annotation Process (Iteration 1, 2 and 3) Adapting CLT in the design of SENTP webpage (iteration 3) SENTP blueprint	Operationality Efficiency Generality Ease of use	Explain why and how the methods are applied in SEN domain Explain the use of DSR methodology to develop SENTP throughout the research (chapter 4, 5 and 6)	
Instantiations	Two prototypes (Iteration 1) Extend SENTP Application (Iteration 2) Extend SENTP application with CLT) (Iteration 3) SENTP ontology	Efficiency Effectiveness	Understand how and why the application works in SEN domain for different special needs issues, age range and learning styles	To be demonstrated in a real domain (chapter 5 and 6)

Table 3.4: Summary of the Research Iterations and Activities

3.7 Summary

This chapter set out the research methodology in accordance with the principles of Design Science Research (DSR). The methodology is executed in five design research steps, as adopted from Vaishnavi and Kuechler (2004): (1) problem awareness (review the existing SEN education environment to identify the requirements and limitation; (2) suggestion of suitable semantic annotation from the knowledge space; (3) development of the main design science research artefact (SENTP); (4) evaluation of the artefact based on synthesising Design Science Research evaluation methods to the SEN environment; and (5) conclusions. In order to achieve the aim and objectives, the research is executed in three incremental iterations. Each iteration aims to build and evaluate set of artefacts to improve the process of utilising semantic annotation in the SEN domain. In the first iteration, the framework method will be developed and evaluated by designing, building, and implementing two prototypes. Then the applicability of the two prototypes in teaching SEN students is compared to select one for the pilot study. The first iteration's outputs are the constructs and a built SENTP model. The second iteration extends the model by adapting a new way of describing the language using existing methods. The school model will be built, designed and pilot tested in Iteration two in a real SEN domain. A qualitative method will be used to gather data at this stage. The feedback from Iteration 2 feeds into Iteration 3, which encourages employing cognitive load theory to extend the SENTP by adapting CLT in the design of the educational user interface. Field testing with larger number of experienced participants will be conducted to generalise the concept of semantic annotation to enhance SEN learning and to evaluate the effects of the cognitive load reduction. The research methodology adopted in this study is Design Science Research (March and Smith, 1995; Hevner et al., 2004). DSR products illustrate the research output for all the iterations. The research products will be identified in the form of consequent constructs, models, methods and instantiations. Finally, the SENTP blueprint method will present a generalised concept of the whole semantic annotation process for enhancing SEN learning. This method will be based on the outcomes of all the research iterations. The SENTP ontology model will be presented as a generalised concept for sharing metadata of any learning content between stakeholders that is applicable for diverse SEN issues, age range, and learning styles.

Chapter 4: Choosing a Tool

Iteration I

4.1 Introduction

The aim of this chapter is to select a semantic annotation tool that can support the process of teaching SEN students. This selection is conducted in order to determine the most suitable tool to carry out the pilot study in schools. This decision is significant, as these schools are cautious with the selection of educational tools because of the impact on class management. Different annotation techniques are explored in this chapter, including manual (Amaya) and semi-automatic annotation tools (OntoMat-Annotizer). Two SEN Teaching Platforms (SENTP) are designed and implemented to compare their suitability in teaching SEN students. The design of the platforms is based on a set of evaluation requirements derived from the literature review. These requirements are achieved through designing an educational poetry website with the selected annotation tools from the experiment. The first step is to design an educational poetry website suitable for different school age ranges, styles and needs. The SENTP lifecycle is developed using a theoretical model derived from Design Science Research theory. The theoretical model is achieved through the empirical analysis of the teaching and learning processes. DSR guides the application procedure and acts as a reference document for situations where the methodology is applied.

The rest of the chapter is organised as follows: Section 4.2 presents the contexts of study and research design and output artefacts. Section 4.3 describes the artefact building and development, while Section 4.4 illustrates the experiments with semantic web annotation tools. The experiments include designing an educational website and testing Amaya and OntoMat Annotizer annotation tool features. Section 4.5 evaluates the first iteration of this study and Section 4.6 summarises the chapter.

4.2 Research Design and Output Artefacts

This iteration applies design research as a miniature iterative process through which the problem space is achieved through artefact development. A method can be seen as a set of steps to follow in order to accomplish a certain task (March and Smith, 1995). In this iteration, a method is conducted in order to construct a SEN Teaching Platform model and find the tools required to conduct the testing in a real SEN environment.

This chapter provides an experiment conducted using various annotation tools techniques (Appendix A). Also, the reasons for selecting poetry as a teaching material are explained. Moreover, various annotation tools are examined to select two for designing and implementing the SEN educational poetry website. Various ontology editors are explored to select the most suitable ontology editor for building the proposed SEN ontology. The comparison between the tools is based on the compatibility for the SEN domain according to the evaluation criteria.

As illustrated in Figure 4.1, an iterative cycle of artefact building, development and evaluation is employed based on the general methodology of Design Science Research by Vaishnavi and Kuechler (2004).

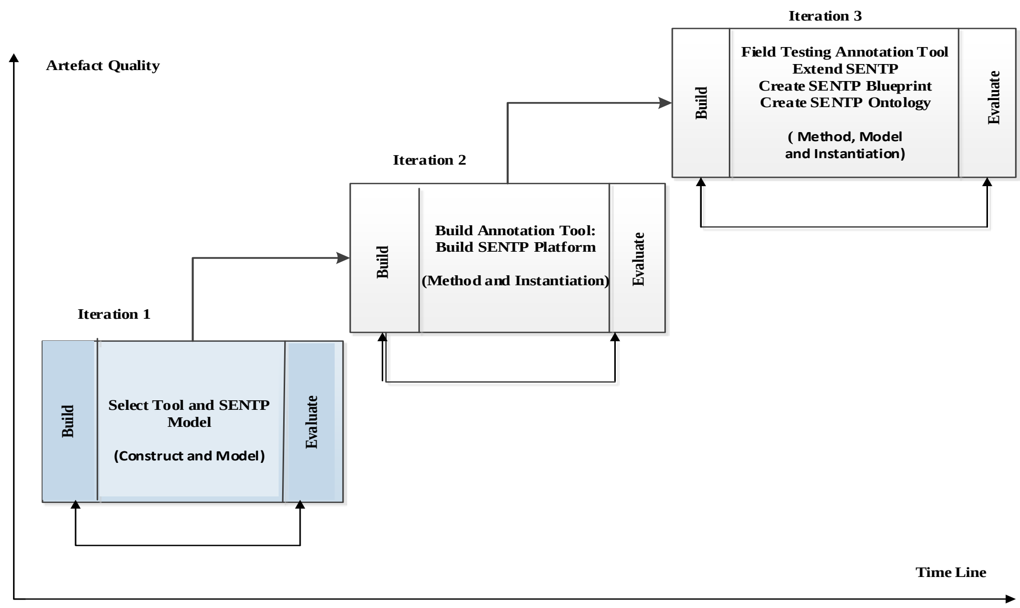


Figure 4.1: Iteration 1 the Overall Framework

This iteration analyses and synthesises the different viewpoints relating to the current teaching methods, outlined in chapter 2, to understand the design requirements. This provides an understanding of the students' requirements for an effective teaching resource. Aiming to work as a solid foundation for the research, and after identifying the practical gap in chapter 2, this iteration seeks to experiment with different types of semantic annotation techniques to select the one most suitable for conducting the pilot study.

4.2.1 Design Science Research Artefact

The aim of this iteration is to construct the SENTP framework, design a model and identify the tools required to design and implement a SEN Teaching Platform. The technique involves applying a process consisting of a sequence of steps, and results in some outputs. As illustrated in Table 4.1, each step applies a method to an input and results in an output that is used as input for the next step.

Steps	Method	Input	Output
1. Construct an understanding of the practical gap in the existing SEN educational domain.	Literature review An awareness of the problem	Literature about the current teaching methods, SEN issues, styles and their teaching requirements.	Construct and model a SEN teaching resource with a set of requirements.
2. Selecting the required tools to conduct the pilot study.	Experiment with different semantic annotation techniques	Construct and model a SEN teaching resource with a set of requirements.	The semantic annotation tools are selected.
3. Design and implement an educational website to use with semantic annotation tools.	Literature review Experiment with the selected tools (Amaya and OntoMat)	The semantic annotation tools are selected.	Two SEN Teaching Platforms are implemented.
4. Evaluate the two SENTPs.	The results against the set of the SEN requirements	Two SEN Teaching Platforms are implemented.	The proposed SEN Teaching Platform is selected.

Table 4.1: Iteration Steps: Input–Output Steps

4.2.2 Evaluation Criteria

The evaluation of the iteration is aimed at assessing the output artefacts. Table 4.2 lists the user requirements, based on the literature, to evaluate the two SEN Teaching Platforms built in this iteration.

No	Requirement	Evidence from Literature Review
1	To use Semantic Web technology to develop SENTP using semantic annotation with different forms.	Devedzic (2006) described education as a rich ground for applying Web technologies and believes that the Semantic Web (SW) is the best way to improve Web-based education. There is much information involved in education and, when we search the web, we get so much unnecessarily information, which makes the search complicated; The Semantic Web identifies information requested by users (Ohler, 2008).
2	The SEN educational poem website used with a SENTP platform should be utilised in an inclusive classroom and can be used for different group age range and styles.	MacBeath et al. (2006) show that many young people with SEN maybe effectivily excluded whithin a mainstream setting, which necessitates that the teaching style focuses on the whole class and enforces strict discipline and little opportunity for individual attention (Read, 2007). Education should be able to reach the special educational needs of all learners. There is great ICT potential that can be explored to facilitate this challenging task (Liu et al., 2007). The teaching staff uses different types of resources in the classroom to eliminate barriers preventing the participation and achievements of SEN students (Glazzard et al., 2010).
3	The SENTP design offers flexibility in the way of annotating different parts of the text (a whole document, a selected text).	Azouaou et al. (2004) define the semantic annotation tool as an instrument for comment, explanation, or any other type of annotation (Liu et al., 2007). 'If you were to observe twenty students with learning disabilities, you would find twenty different ways, the condition manifests itself.' (Turnbull et al., 2002)
4	The SENTP user interface is user friendly with suitable colours, fonts, and images that suites age range	Teaching staff use visual and auditory methods with different types of resources to achieve good results (Glazzard et al. 2010). As argued in a UNESCO guide (2000) 'All pupils gain when teachers adapt the curricula and their teaching styles to suit the range of diversity that is found among children in any class. Usually these adaptations require little extra equipment but lots of creativity.' (McConkey, 2000) SEN students have difficulty in absorbing abstract ideas (ATL, 2013).
5	The SENTP should offer different forms of annotation (i.e. image, audio, text, various font sizes).	Aurthor (2011) stated that it has a unique ability to convey complicated topics in a way that viewers can engage and understand thoroughly. Sound can be used to enhance learning, as noticed by Bishop and Sonnenschein (2012). Results demonstrate that a range of procedural alternatives based upon the use of video have led to positive and effective interventions for a number of target behaviours (Rayner et al., 2009).

6	The SENTP should be evaluated with two types of annotation tools. One without building an ontology and the other one with an ontology to compare its applicability for the pilot study.	Uren et al. (2005) refered to two frameworks for annotation in the Semantic Web (SW), the W3C annotation project Annotea, and CREAM. Annotea is a W3C project whose main format uses RDF and the documents that can be annotated and are limited to HTML or XML-based documents. The annotation tools are manual, semi-automatic or automatic (Slimani, 2013). Davedzie (2004) explains that the ontology can be used as a tool to help in sharing and reusing knowledge. Rogozan and Paquette (2005) discuss an approach that uses skills/performance and learning-domain ontologies to annotate resources in a standard manner, and propose a framework for managing ontology changes.
7	The SENTP should be easy to use, maintain and not expensive.	The selection of strategies must also be appropriate for the developmental level of the students in the teacher's classroom. Extra care should be taken in selecting strategies to be implemented in classrooms with very young children or children with special needs (Picard, 2004).
8	The SENTP should be accessible anytime and anywhere, even if there is no network.	Koper (2004) noted that semantic annotation can support education through supporting the teachers with performing their tasks online and in lifelong learning.
9	The process of annotation should follow simple steps so that staff with limited IT skills can use it with limited mistakes to avoid any disruption in the flow of the lesson.	Much of the literature (see DfES 1989; DfE 2010) flags up disruption as a cause for concern when including behavioural, emotional and social difficulties (BESD) children in mainstream primary schools, and a recent article in the *Times Educational Supplement* (2010: 16), which stated that 'disruption in the classroom is the biggest behaviour challenge to teachers', supports this concern (Peaston, 2011).
10	The SENTP should show the ability to enhance students' understanding of the topics.	Weal et al. (2012) posited that 'semantic annotation provides novel mechanisms for both student feedback and increased understanding of the learning' 'How can teachers help all their pupils to learn? Pupils have to be helped to understand what they are trying to learn.' (UNESCO, 1993) 'Autistic children have difficulty understanding or using language.' (ATL, 2013)
11	The SENTP should increase students' attention and concentration in the lesson.	Yang et al. (2004) stated that annotation could benefit learning by helping students to focus on the annotated concept or specified sentence. SEN students exhibit poor concentration and a short attention span (ATL, 2013).

12	The SENTP should increase student engagement and motivation in lessons.	The use of visual aids such as images, video or cards to deliver educational contents increases the learners' interests in certain subjects, makes the learning process more enjoyable, retains students' interest for a longer period, which leads to enhance the students learning process (Zane, 2016) Children with ADHD often experience low motivation toward learning. Bolliger et al. (2010) define motivation as 'one of the significant psychological theories in education' in order to have successful learning. 'SEN students have a lack of imagination', 'poor listening skills and difficulty in following instructions addressed to the class as a whole.' (ATL, 2013)
13	The SENTP should reduce behavioural problems.	Teachers have difficulty coping with their teaching responsibilities while responding to emotional problems, severe academic deficits and other problems (Soodak et al, 1998).
14	The SENTP should be able to support the teaching staff (save time, better class management and support staff training).	Management in class requires a lot of effort (Department for Education and Morgan, 2016). Children with SEN require more time from the teaching staff (Klinqner et al., 1998). It is apparent that some teachers who do not have the appropriate training to respond to SEN are overwhelmed by anxiety as they cannot respond effectively to students' socio-emotional and academic needs, and sometimes cannot get the necessary support and resources from managers, as Scruggs and Mastropieri (1996) emphasise. The use of their time is, therefore, critical to effective teaching and learning (UNESCO, 1993). Intensive behavioural intervention (staff training; parent training; and teacher training) have an effective influence on autistic school-aged children (Fava et al., 2012).
15	The annotation process should be accurate.	'A very accurate manner of annotating resources. Can support the needs of different users.' (El-ghobashy et al., 2014)
16	The SENTP should be able to replace or reduce the current manual methods.	'It enables educators to teach students how to communicate alternatively through selection and combination of visual representations, symbols, words, gestures and sounds.' (Deliyannis et al., 2008)

Table 4.2: A list of User Requirements Based on Literature

4.3 Artefact Building and Development

The building stage implies identifying the initial steps for the process of constructing the SDM framework. First, building the artefact involves problem awareness and suggestion. The initial stage involves using the literature review to analysis existing literature about SEN teaching resources. Also, via an experiment with different semantic annotation tools, the most suitable tools for the research should be identified and an understanding of the characteristics required obtained. Then, the SENTP model is designed and constructed according to the set of the evaluation criteria in Section 4.2.2. Two semantic annotation tools are used (Amaya, OntoMat Annotizer), with an educational website to compare and enable a deeper understanding to suggest which tool to employ in the real SEN domain. Figure 4.2 sketches the developmental process of the experimental framework (SDM) model using OntoMat, which requires the building of ontology, and using Amaya, which does not require building an ontology.

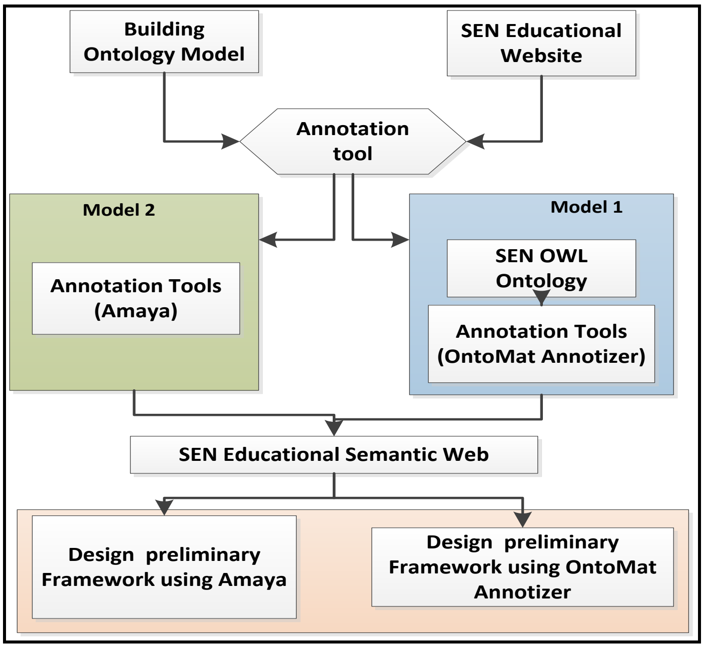


Figure 4.2: An Overview of SEN Development Media (SDM) Framework

Diagram 4.3 describes the SENTP approach based on the DSR adopted in this study. The semantic annotation tools evaluation was contingent on the literature review and the requirements set at the beginning of this chapter.

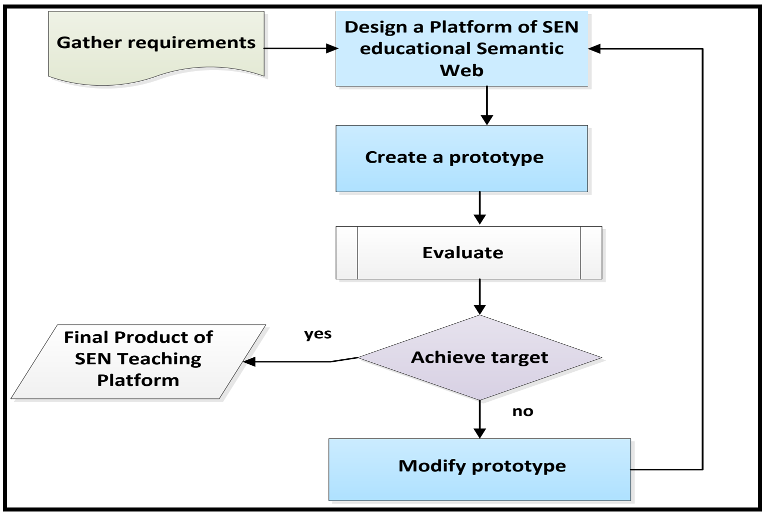


Figure 4.3: Design SENTP Model Flowcharts

4.4 Tool Selection

This section presents the experiment with two annotation tools to compare and prove the applicability of the proposed annotation approach in a real environment. Two prototypes are designed and implemented using OntoMat and Amaya. The first prototype is designed and implemented with OntoMat, a design which requires SEN ontology. The second prototype uses Amaya, which does not require the creation of SEN ontology. Both prototypes are implemented with an educational website. The first step in this experiment is the design of an educational website for teaching poetry.

4.4.1 Design Educational Poetry Website

The proposed educational website is coded with HTML as both annotation tools work with websites coded in HTML. The content of the website comprises poetry, which includes a selection of poems relating to different year groups. The poems provide teaching material used for this research, chosen from the national curriculum for ages

3–16 (National Curriculum, 2014). Moreover, understanding poems is seen as a challenging task for SEN students. Understanding the underlying meaning of poetry is especially a challenge for autistic children (Perko, 2002). Also, poems are achnowledged as a motivating and entertaining topic for SEN students, as rhyme is seen as the ideal teaching method for younger ages. In addition, poems allow the student to revisit and reuse key concepts and vocabulary (City of Bradford MDC, 2016). To design the poetry website for the experiment, three age ranges are selected to provide applicability across the National Curriculum age range. The age groups selected are: from the younger age of 2 and a half to 9 (children's poems), from 10 to 16 (teen poems, romantic poems), then 16+ (English poems, dark poems, wedding poems and American poems). Seven options are selected to cover the SEN students' needs based on the literature review in chapter 2, as depicted in Figure 4.4. The options are 'Bigger', 'Smaller', 'Sound', 'Images', 'Image and Information', 'Video', and 'Information'.

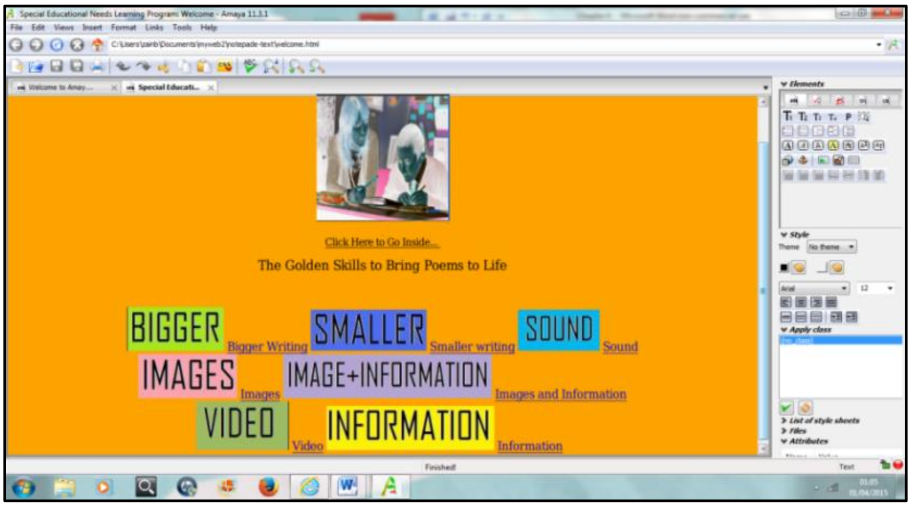


Figure 4.4: SENTP User Interface –Main Page-Version 1

For each option, a selection of poetry styles is presented to cover poetry for all the sample age ranges selected, as depicted in Figure 4.5, which presents a screenshot of the first user interface, the second page.

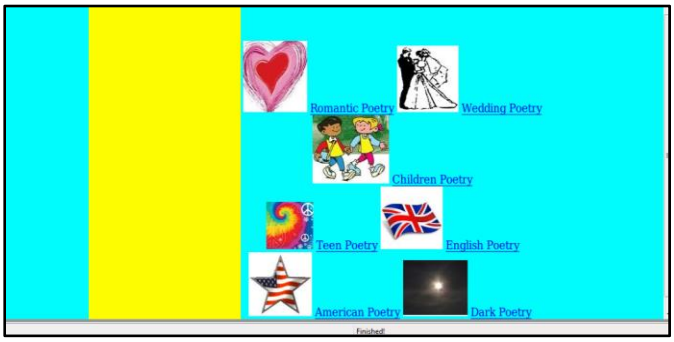


Figure 4.5: The User Interface, Page 2

Each style leads to a separate page, with a selection of poems as depicted in Figure 4.6, which shows the romantic poems page with a selection of romantic poems from the Teen Poetry category.

Figure 4.6: GUI of the Romantic Poems Page

4.4.2 Building the SEN Ontology

Ontology is an explicit description of a shared conceptualisation in the area of interest (Handschuh et al., 2002, Cimiano and Handschuh, 2003). To build ontology, various stages are required, including knowledge acquisition, knowledge modelling, and knowledge annotation and reuse (Millard et al., 2006). There is an important question to identify the ontology's scope 'what the ontology used for?' The expected use of the ontology is to annotate the SEN poetry website as a SEN resource to be used in class. The basic components of the ontology are classes, properties and restrictions (Sachs, 2006). To build the SEN ontology for this study, different versions of Protégé were explored and Protégé 4.1 was selected. The ontology model for this research was built using OWL2, which is fully supported, and modelled with the Protégé 4.1 beta ontology editor. The process of authoring the SEN ontology was as follows: First, a line of the poem was reviewed, the poems were interpreted, some of the words as classes were identified, then, the concepts and relationships were identified to develop the SEN ontology (classes and properties). Figure 4.7 depicts extract of the SENTP ontology classes with annotation structure. For example, by interpreting the 'At the Zoo' poem, we have Person, Animal, and Poem as a class. By defining the relationships between them, "Children's poem" is a poem, 'At the Zoo' is a Children's poem and the 'At the Zoo' poem is written by a Poet. Instances can be defined to be objects of the above classes. For example, for the 'Animal' class: 'Camel', 'Black Bear', 'White Bear', 'Grey Wolf' are instances. The relation existing between any two classes is defined as an object property. Any object property has a domain class (from which class) and a range class (to which class), e.g., is-a (Poem, Children's-Poem), is-a (Person, Poet). Ontological relations are manually identified by the researcher and evaluated using the experiment. Table 4.3 presents an extract of the proposed relationships for SENTP ontology relationships. The datatype property of any class is a property that gives values for instances. It is a relationship between class and a datatype value (String, Integer, Float), e.g. has-Colour (Animal, String). These relationships are defined in an ontology language such as OWL, as presented in Figure 4.8.

Subclass	Relationship	Class
Children Poem	is-a	Poem
Romantic Poem	is-a	Poem
Wedding Poem	is-a	Poem
Teen Poem	is-a	Poem
English Poem	is-a	Poem
Dark Poem	is-a	Poem
American Poem	is-a	Poem
At the Zoo	is-a	Children Poem
A Kitten	is-a	Children Poem
One Two Three	is-a	Children Poem
Little Jack Horner	is-a	Children Poem
Poor Dog Bright	is-a	Children Poem

Subclass	Relationship	Class
At the Zoo	has-a	Animal
Animal	is-a	Elephant
Animal	is-a	Monkey
Animal	is-a	White Bear
Animal	is-a	Black-Bear
Animal	is-a	Camel
Animal	is-a	Wombat
Animal	is-a	Grey Wolf
Camel	has-a	Hump
Elephant	Waving of-his	trunk
Grey Wolf	Eats-a	Mutton
Mutton	Eaten with-a	Wolf-Maw

Table 4.3: Extract of the Ontology Relationships

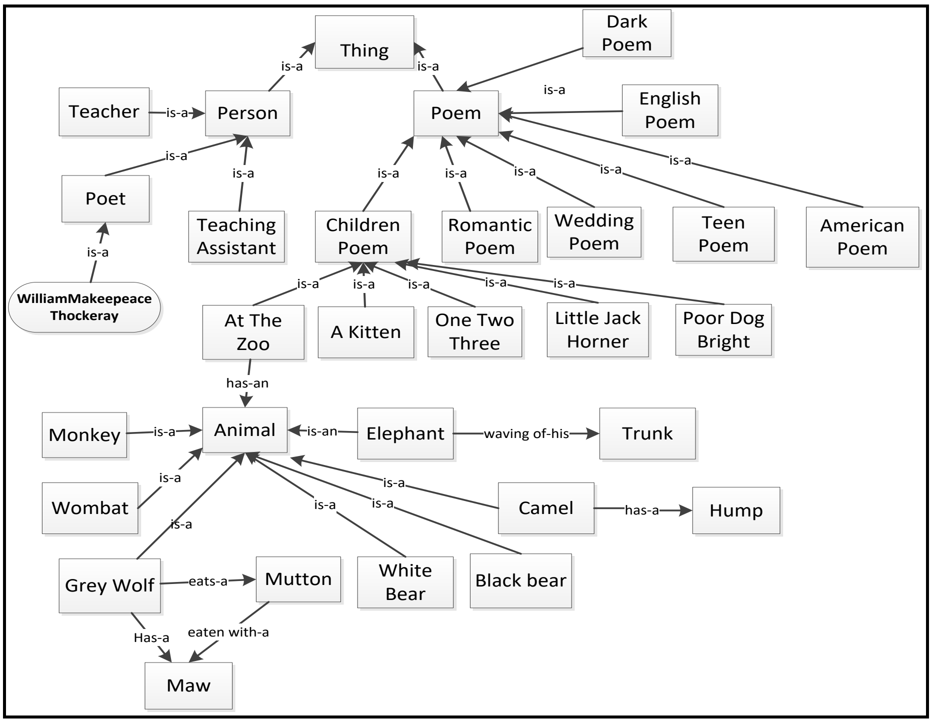


Figure 4.7: An Extract of the SENTP Ontology Model

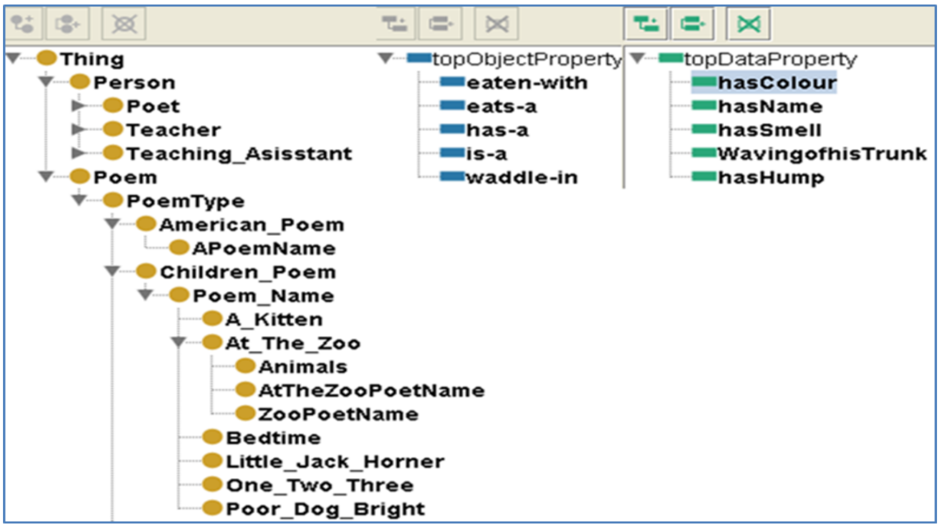


Figure 4.8: Snapshot of the SENTP Ontology Model Defined in Protégé

(See Appendix A for more evidence)

4.4.3 Implementing SENTP using Protégé 4.1 Beta

Protégé developed at Stanford University and authorised by the World Wide Web (WWW) Consortium (W3C). It is a free open source ontology editor integrated environment and a standalone application (Corcho et al., 2003). The editor supports the building of ontologies in different languages, such as RDFS and OWL, using plug-ins. The ontology editor and knowledge-based framework with the development framework that provides the necessary manipulations and queries from the ontology are freely available and facilitate defining ontology concepts (classes), properties, taxonomies as well as class instances (Deveszic, 2006). All the metadata about SEN students, SEN teachers and the poems are structured and defined by the SEN ontology designed using Protégé 4.1. It describes the entities, relationships and data involved as well as adding any restrictions required. Protégé 4.1 provides full support for OWL, as utilised in this research. The SEN ontology is extendable and provides a plug-and-play environment that makes it a flexible base for rapid application development (Knublauch et al., 2005). Protégé can ultimately create and show the SEN ontology, which is designed in order to be used with the OntoMat Annotizer.

4.4.4 Semantic Annotation Tools and SEN Learning

Annotation is a mechanism to associate metadata with Web resources to provide a meaning to its content (Bechhofer et al., 2002). Handschuh and Staab (2003a) describe the annotation as a set of instantiations attached to a HTML document. Annotations are external comments, additional information, notes or remarks that can be attached to any Web documents (Kahan et al., 2002). Recently, there have been many annotation tools developed such as manual, semi-automatic or automatic. In this research, Amaya is used as a manual annotation tool and OntoMat-Annotizer as a semi-automatic annotation to evaluate the benefits of using semantic annotation in teaching SEN students and to compare the two tools to select one for the pilot study. Glazzard et al.'s (2010) ideas state that encouragement in learning is increased for SEN pupils by offering different teaching styles, which are mainly visual in nature. In addition, the alternative methods of written recording for children with learning difficulties, which are acknowledged as images, charts, spoken words, ready-made texts, ICT, sorting and labelling, symbols, scribing and numbers, are taken into account. The proposed SEN model comprises pictures, text, video and sound as forms of annotations for effective results.

The process of annotation is conducted by reviewing a line of the poem, interpreting the verses then identifying some of the words for annotation. Figure 4.9 illustrates our use of the term 'Metadata' in this study and the relationships between these items.

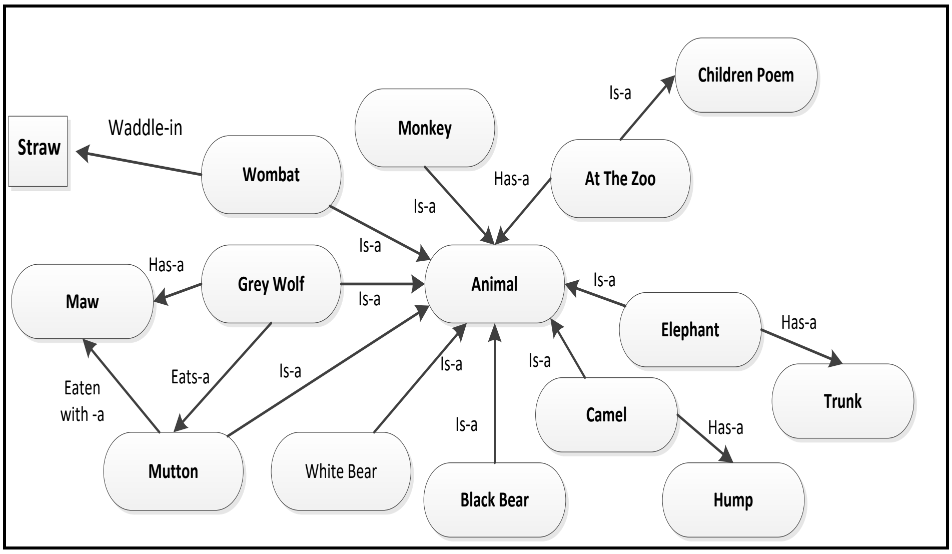


Figure 4.9: An Example of Ontology of Poem

4.4.5 OntoMat Annotizer

OntoMat is a web page annotation tool utilizing a CREAM framework and working with OWL ontologies. Some features are user friendly, such as drag and drop annotation creating (Handschuh et al., 2003). OntoMat is selected for this research as described in Section 2.5.3. It is a user-friendly interactive web page with annotation tools that include an ontology browser and an HTML browser (DAML Tools, 2015). Moreover, a semi-automatic annotation tool with ontology is regarded as a reasonable choice to compare. Furthermore, as accuracy is assumed as one of the important issues required within the educational environment, using ontology helps to constrain the possible relations between concepts, consequently reducing errors in the annotation process, as clarified by Cimiano and Handschuh (2003). The SEN ontology created with Protégé and OWL 2 and the poetry website were imported to the OntoMat tool. Ontologies are used to encode the meaning of the poem text into the web page. This helps the intelligent agent (OntoMat) to understand what the web page is about; the annotation process starts by selecting the class where the text from the websites fits, then dragging the text from the website to the class – associating the text with the description of the class. This software shows the collaboration between the design of the ontology and the website. The Protégé ontology is loaded on one side and the educational website coded with HTML on the other side. Highlighting any text from the poem, such as the writer name, and dragging it to the Author class, adds the writer name to an individual in the Author class. Figure 4.10 presents the structure of the SENTP model combining the SEN OWL ontology designed in Protégé 4.1 and the SEN educational website created in HTML and adding the OntoMat-Annotizer as the selected annotation tool for this research builds the SEN teaching platform (SENTP). The annotation created and an extract of the text is presented as an instance as depicted in Figure 4.11.

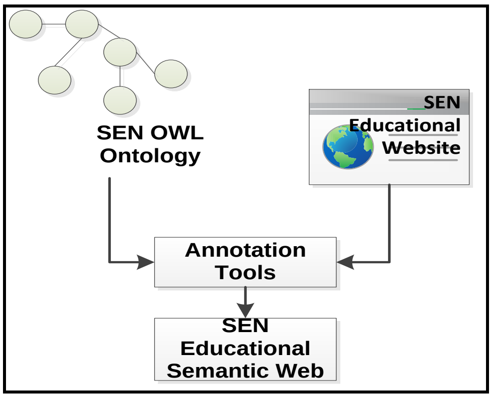


Figure 4.10: Adapting Semantic Web with SEN Education

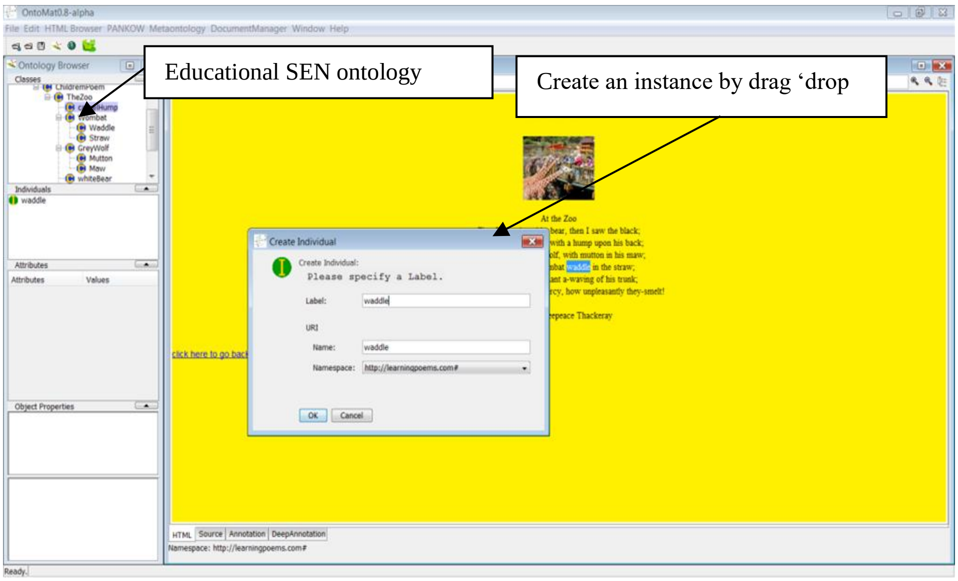


Figure 4.11: Representation of Creating Author Instance

Figure 4.12 illustrates the progress of the annotation of a children's poem; on the left of the screenshot is the ontology designed using Protégé with all the classes, entities, attributes and relationships. The right pane displays the poem document.

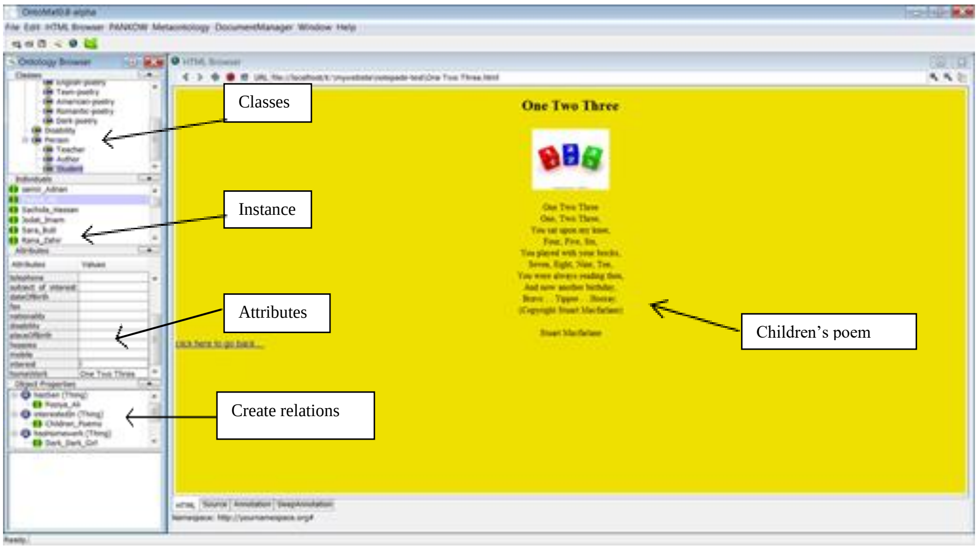


Figure 4.12: Create an Annotation using OntoMat

Although the process of the annotation is fast, it requires sound ICT skills for editing. Also, it is difficult to use different forms of annotation relevant to the existing methods used, such as images, sound or videos, which is regarded as essential in teaching SEN students. There is another version of OntoMat called OntoMat Media, which is recognised to work with images and media annotations, but it is not suitable for use by teachers with limited IT skills. Table 4.4 summarises the outputs that can be obtained from the DSR effort in Iteration 1, which comprises Constructs, Models, Methods, Instantiations and Better Theories.

Step	Output	Description
1	Constructs	The conceptual vocabulary for teaching SEN students in the poems domain.
2	Models	A set of statements expressing the relationships among constructs (Fig 4.8).
3	Methods	A set of the steps used to perform the task. This is done by experiment on two annotation tools and a comparison based on the literature review (Table 4.1).
4	Instantiations	The final output from the DSR, which operationalises construct, models, and methods by implementing two SENTPs (Section 4.3).
5	Better theories	Experiment results in choosing one of the semantic annotation tool, which is Amaya in this research (Section 4.4).

Table 4.4: Outputs of Design Science Research

4.4.6 Amaya

As described in Section 2.5.2, Amaya is a text annotation tool, a Web client that acts both as a browser and as an authoring tool. The kinds of documents that can be annotated with an Annotea framework are limited to HTML or XML-based documents (Uren et al., 2005). In our context, we chose the HTML format and used the XPointer method for locating annotations within a document (Poems). It is a manual annotation tool, which allows the school domain users to create manual annotations. See Figure 4.13 for the annotation process steps; a user who annotates the resource with the tag can be seen in Figure 4.14.

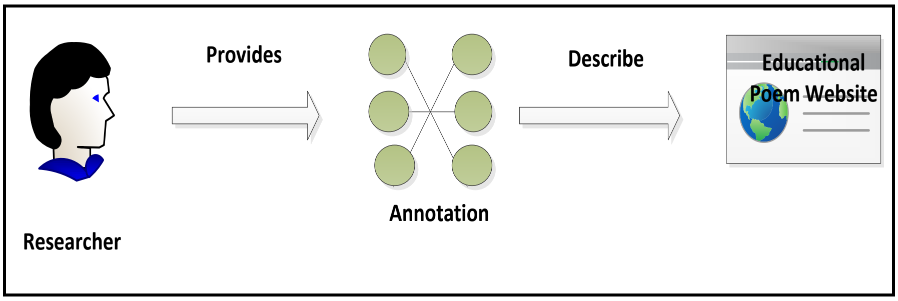


Figure 4.13: The SENTP Annotation Process Steps

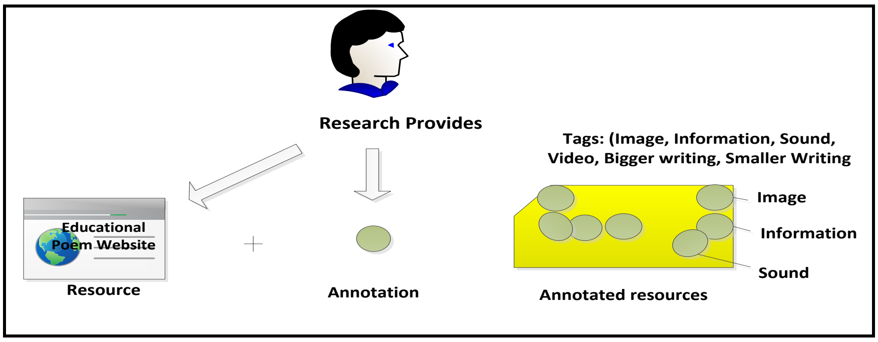


Figure 4.14: The SENTP Tag Annotation Model

4.5 Selection of Amaya 11.4.4

Amaya has been set up for Annotea W3C projects, which provides a collaboration environment of sharing Annotea (2001). The idea of supporting SEN teaching is to enable the required annotation for SEN students as notes, information, images, and some SEN symbol systems. The annotations are modelled like metadata using a combination of Resource Description Framework (RDF) with Xpointer, Xlink and HTTP. Furthermore, Amaya can work on several documents with different formats, such as (X)HTML, MathML and SVG (Kahan, 2002). Amaya is a manual method and does not require complicated technical skills, it is easy to use and the software is available free from the internet. Amaya allows users to browse and author web page. The web page can be uploaded onto a server. Also, Amaya maintains a consistent internal document model following to the Document Type Definition (DTD) to enable other tools to process the data safely (W3C, 2016). Links can be created like hypertext and include annotations, which are external information that can be attached to the Web document or part of the document. This annotation process could easily be used to support SEN related tagging. All annotations will provide extra information and images for the documents published on the Web. Consequently, all annotations are saved and can be used at any time as required. Remote annotations can be saved to the annotation post server, and local annotations can be saved to the annotations directory. This flexibility can be utilised if there is no network at the school site. All the images are in JPEG, PNG, and GIF bitmap as Amaya supports these types of graphics formats, and it describes annotations using a particular RDF annotation schema. In Amaya, the metadata consists of the title of the annotation, the author's name, the annotation type, the creation date, the title of the annotated document and the last modification date. The metadata will keep all the information details in case it is required.

This research uses Amaya as an annotation tool via an educational system for SEN teaching. The website depicted in Figure 4.4 is a poetry website that includes different styles of poems. This website was developed to add extra information for SEN by adding annotations to each poem. For example, when a SEN student needs to learn about children's poetry, most of the words in the poem are tagged with additional information and a picture to represent the word. Amaya displays a pen image ( ) to show the annotation and when clicked it will display the stored annotation.

4.5.1 Designing platform for in-school experiments

Annotations can be represented by comments, images, notes, explanations, or other remarks that can be attached to a Web document (Amaya, 2015). The platform for in-school experiments uses annotations, which include images, information, sounds, videos and the use of bigger or smaller fonts. The selection of these annotation forms is based on literature review which studies different special needs cases as described in section 2.2, and the effective existing methods used in schools as described in section 2.3. Amaya presents the annotations with an icon ( ) indicating that an annotation is visually embedded in the poem text. Double-clicking the icon ( ) results in the annotation text and other metadata (e.g. images) being presented in a separate window which make it easy for special need student to focus on a specific learning material. On a single-click of this icon ( ), the text that was annotated is highlighted in case the activity designer/researcher or the teacher needs to specify the annotated parts of the teaching material for maintenance.

There are two choices of annotation methods considered in this research to support SEN students, which are annotating a whole document or annotating selected text. Figures 4.15 and 4.16 show a screen capture of Amaya when creating an annotation on a Zoo poem. Figure 4.17 depicts a screen capture of Amaya when the words 'White Bear' are selected from the children's poem and if images are required. Figure 4.18

present the HTML code for the Zoo poem and Figure 4.19 presents the annotation links code.

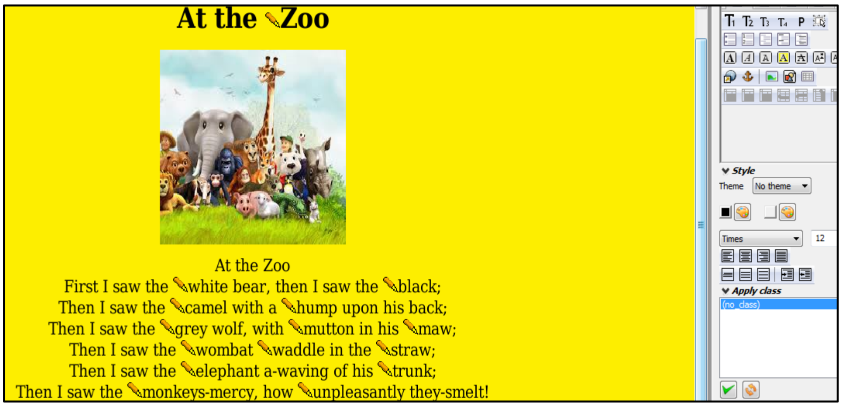


Figure 4.15: Annotating a Poem 'At the Zoo' with Amaya

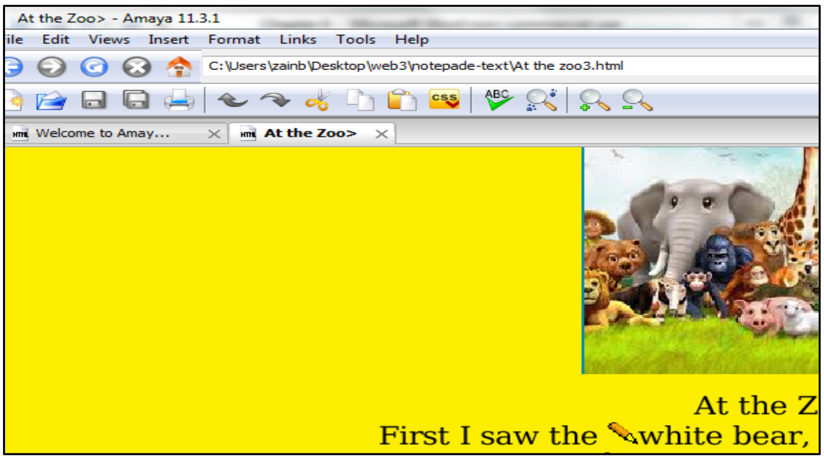


Figure 4.16: A Snapshot Illustrating the Pen Used for Annotation

Figure 4.17: Snapshot Illustrating the Annotation Results of 'White Bear'

Figure 4.18: Representation of Annotation for Example 'Zoo Poem'

Figure 4.19: Representation of Annotation Links for Example 'Zoo Poem'

Figure 4.20 depicts the annotation of the 'Bear' from the children poem 'At the Zoo'.

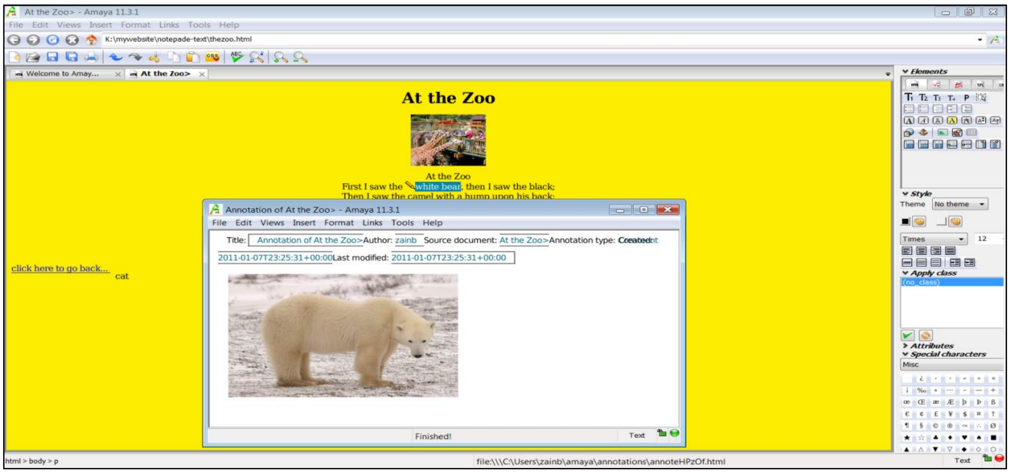


Figure 4.20: The Annotation Result Window

Designing a platform for in-school experiments starts with loading the poem website in Amaya and adding the semantic annotations to each poem. The annotations added are further information, different fonts, multimedia or images. All annotations can be saved and used anytime. The system starts by choosing the type of annotation appropriate for the students, then select the style of the poem and the poem appropriate for each group. In Amaya XLink attributes attached to all the annotation icons represented as pencil (). To see the annotations, the user clicks on the pen as indicated in Figure 4.21. SEN students can use the pencil icon to work independently. The pencil can be used as an indication point to get the feedback query required. While having a tagged pen can be used as a method for teaching SEN students, the user has the option of hiding the tagged pen if they find it obstructive. Since we have the choice to save the annotations locally in one or more annotation servers, local annotations can be saved in the same way as saving the document with Amaya. Saving annotations in a shared annotation post server requires converting them from local server to shared one by selecting ‘Post to the server’ from the Tools/Annotations menu to save remote annotations. Saving annotations to a shared server will cause the permanent removal of local annotations. All annotations are saved locally in this research because some of the schools have no access to the internet. However, they can be changed to a shared server if required.

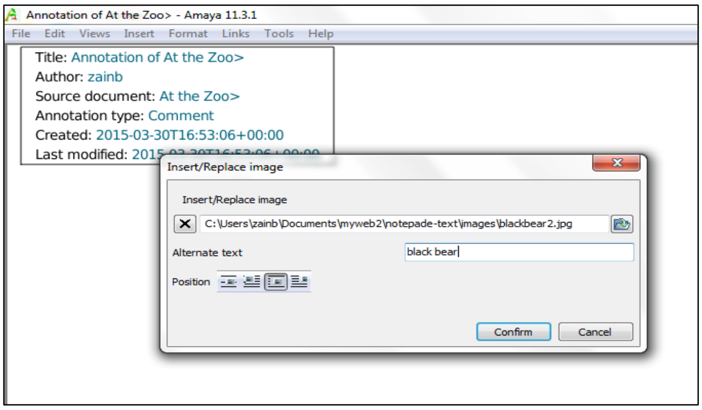


Figure 4.21: Part of the Process of Annotating a Single Word

Figure 4.22: GUI Annotating the Children's Poem 'At the Zoo'

Figure 4.22 presents the results of the annotation process when the pen image is clicked on 'Black Bear'. Figure 4.23 illustrates the text selection choice of the annotation available with the Children Poem 'At the Zoo'.

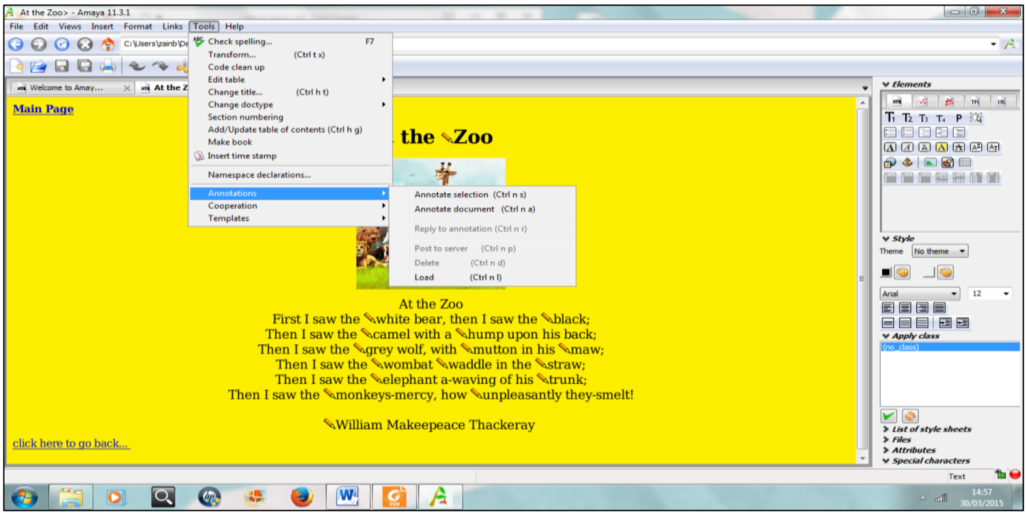


Figure 4.23: Screenshot of Amaya Annotation Types

Amaya allows authors to edit the contents and attributes of XML documents. Figure 4.24 illustrates the ‘At the Zoo’ poem in XML format.

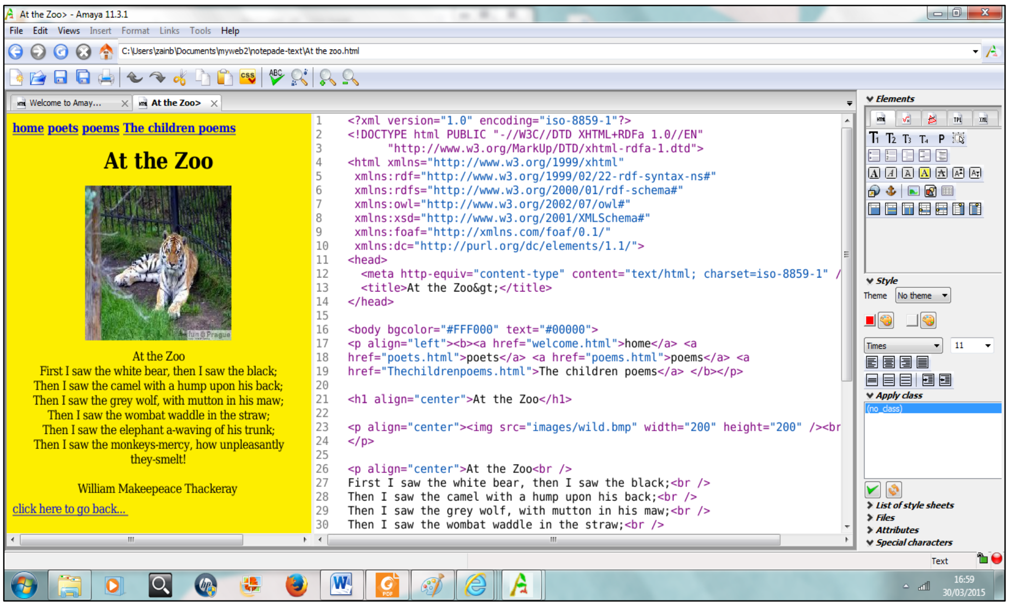


Figure 4.24: Illustration of the Poem in XML Format

The content of Figure 4.25 highlights the metadata annotations. This includes author name, the title of the annotated document, the type of annotation, the date of creation, and the date of the last modification.

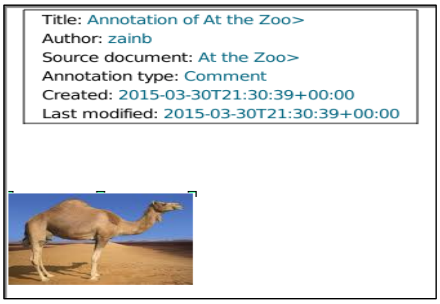


Figure 4.25: The Metadata of the Annotation

4.6 Evaluation of Iteration 1 Artefacts

Evaluation is a crucial step in any research project as it reveals strengths and weaknesses that can be worked on in the future (Hevner et al., 2004). The evaluation is designed to ensure and demonstrate the effectiveness of one of the proposed annotation tools as an approach, which offers support to SEN learners and teaching staff in the teaching of poems in class. The evaluation procedure for this study is a criteria-based evaluation, as defined by Cronholm and Goldkuhl (2003). Criteria-based evaluation is one of the most frequently used evaluation approaches in the IS field, which evaluates according to predefined criteria, as set in Section 4.2.2. This type of assessment has a small degree of participation, as stated by Cronholm and Goldkuhl (2003). Table 4.5 describes the characteristics of the criteria-based evaluation of the SENTP system, based on Cronholm and Goldkuhl (2003, table 4, p. 71).

Main perspective	**Depending on the character of the criteria**
What to achieve knowledge about	The quality of SENTP according to the perspective that is underpinning the criteria in Section 4.2.2. At this stage, the main goal is choosing the tool.
Data sources	The SENTP, descriptions of SENTP, descriptions of the criteria.
Deductive or inductive	Deductive
Who will participate	Evaluator (researcher)
Why we chose this type	We require focused evaluation, two IT systems available to compare at hand, no users or participants available.

Table 4.5: Criteria-Based Evaluation of SENTP (Cronholm and Goldkuhl, 2003)

For Amaya different types of metadata (textual, image or multimedia) can be used as an annotation by following simple instructions (requirement number 1). Presenting annotations in different forms is essential to enhance SEN learners because picture exchange is one of the crucial methods in teaching an autistic child (Bondy, 2010; Charlop-Christy et al., 2002). Moreover, Glazzard et al. (2010) state that using graphic devices within a text and constructing key visuals from the text is an effective, engaging teaching method. The SENTP user interface provides the ability to select the type of metadata, child's age range, and the poem style required (requirement number 2) to tailor to different SEN students' issues. Also, it is important to prepare the right learning material for each student. Roy (2010) stated that children use different types of symbol systems for effective learning.

Amaya has the ability to offer annotations to different parts of the teaching material as a whole document, from the position of the cursor or to annotate a selected text (requirement number 3). It is a friendly user interface, which offers different colours and fonts for the text, and can insert different images according to the group requirements (requirement number 4). Amaya can offer different forms of annotation (i.e. image, audio, text, various font sizes) (requirement number 5) and can be tested with different types of annotation tools (without building an ontology) (requirement number 6). Amaya is easy to use, maintain and as it is available as freeware does not have a cost implication (requirement number 7). Uren et al. (2005) point out that Amaya is a good example of a single point of access environment because the user can make annotations via the same tool they use for browsing and for editing text, making Amaya an excellent tool to use within a busy educational domain. It allows accessibility as the staff can access the SENTP using Amaya anytime and anywhere, even if there is no internet engine, because it can be on a shared server or stand-alone (requirement number 8) (W3C, 2014). The process of annotation in Amaya follows a simple process for staff with limited IT skills (requirement number 9). The SENTP is designed using Amaya to be adapted to a full range of SEN, as it is designed to offer different options to meet this need (requirement number 2).

On the other hand, OntoMat annotation requires some technical skills and computer knowledge to offer different types of annotation styles. Hence, Amaya is more flexible (requirement number 9). OntoMat annotation is built with an open source OWL2 with a Protégé 4.1 plugin, which is not an easy process for staff without some special computer skills (requirement number 9). OntoMat is not considered as an easy to use tool within the school setting (Staab and Handschuh, 2002). In addition, it needs human intervention with a sound knowledge of technical skills at some annotation level, which can be difficult to get in a demanding educational setting, which does not meet requirement 7. OntoMat supports remote shared annotation only. This limits the use to classes supplied with internet connection (requirement number 8). OntoMat can offer SENTP to different needs, but requires specialised computing knowledge, and requires specialist support to maintain it.

This comparison shows that Amaya provides some support for ontologies, where OntoMat-Annotizer has full support for ontologies. The drawback with OntoMat-Annotizer is in the metadata that provides the content of the Web; authors must create and annotate the content (Handschuh and Staab, 2002). Thus, the annotation process is more complicated, requires domain skills, and should employ annotators with an associated extra cost. There is a greater authoring effort for Amaya than OntoMat-Annotizer. Nevertheless, it can be managed with simple IT skills knowledge, and a set of instructions can be followed by the teaching staff to accomplish the annotation task required. Amaya is based on XML or HTML; OntoMat-Annotizer is based on HTML only. After the investigation, Amaya was chosen as a good example to use for the pilot study because it can overcome some fundamental limitations of the existing teaching methods used in SEN classes. A summary of the findings by the previous work, which is based on the literature, can be seen in Table 4.6.

	Amaya	OntoMat-Annotizer
Efficiency		x
Cost	x	x
Maintenance	x	x
Ease of use	x	
Time	x	x
Completeness	x	
Simplicity	x	
Support for ontology		x
Elegance	x	
Generalisability	x	
Understandability	x	
Quality of result	x	
Automation		x
Authoring effort	x	

Table 4.6: comparisons between Amaya and OntoMat

Table 4.7, which follows, shows the experiment results supported with the literature review to select the most suitable tool for testing in real SEN educational environment. The comparison was between Amaya and OntoMat Annotizer according to the evaluation criteria outlined in Section 4.2.

Requirements	Amaya		OntoMat		Results
	Experiment	**Evidence from Literature**	**Experiment**	**Evidence from Literature**	
1 To use Semantic Web technology to develop SENTP using semantic annotation using different forms.	The Semantic Web is used to develop the SENTP using different forms of text, images, and audio.	'Amaya can offer different forms of annotation such as text, image or audio.' (W3C, 2014) 'Amaya uses XPointer to indicate where an annotation should be attached to a document.' (Uren, V et al., 2005)	Drag 'n'Drop	'Drag'n'drop helps to avoid syntax errors and typos, and a good visualization of the ontology can help to correctly choose the most appropriate class for instances.' (El-ghobashy et al., 2014)	Target achieved
2 SENTP poetry website should be utilised in an inclusive classroom and can be used for different group age range and styles.	The website is designed to present different options (smaller, bigger, sound, image, image and information and video).	'Manual annotation ...requiring multiple ontologies, can be beneficial to support the needs of different users.' (Fensel and Morozova, 2010) 'It is also vital that the subject matter is appropriate for the individuals in the class.' (ATL, 2016)	The website is designed for different needs, styles and ages.	'Document format, HTML.' (Urena et al. 2006)	With Amaya, the website is coded in HTML and designed for different needs, styles and ages.
3 The SENTP can annotate different parts of the text (whole document, selected text).	We have three choices for creating an annotation: annotate a whole document, annotate the position where the cursor is, annotate the current selection.	The user has three choices for creating an annotation: annotate a whole document, annotate the position where the caret is, annotate the current selection (Kaha and Koivunen, 2001).	We annotate the selected text.	'Allows the annotator to highlight relevant parts of the web page and create new instances via drag'n'drop interactions.' (Semantic Web Annotation and Authoring, 2013)	Amaya offers the user three choices for creating an annotation.
4 The SENTP user interface should be user friendly and include suitable colours, fonts, images for different SEN group requirements.	Tested user-friendliness and ability to select different colours, fonts, images.	'Annotea, with its emphasis on collaboration has influenced the development of some excellent systems with good user interfaces that are well suited to distributed knowledge sharing.' (Uren, et al., 2005)	Tested user-friendliness Drag-and-Drop creation of instances.	'The annotation interface in OntoMat is used to annotate texts in a user-friendly manner.' (Ciravegna et al. 2002) 'OntoMat-Annotizer is a user-friendly interactive web page annotation tool	Amaya offers different annotation types. OntoMat offers text annotation only.

		‘It is a user-friendly interactive Web browser and editor built on the Annotea framework.’ (El-ghobashy et al., 2014) ‘Many of the annotation tools rely on specialized browsers to offer a better user interface. One of them is Amaya’ (Cimiano et al., 2005, table 2; Staab et al., 2000)		which supports the user with the task of creating and maintaining ontology.’ (http://ontoweb-lt.dfki.de/sem_ann_tools_set.htm’) ‘A Web browser displays the page being annotated and provides user-friendly function, such as drag and drop creation of instances.’ (Kashyap et al., 2008	Both are user friendly
5 The SENTP should offer different forms of annotation (i.e. image, audio, text, various font sizes)	Tested annotating collection of poems for different ages and styles with different annotation types (image, audio, text, different font sizes).	‘Annotation types can be defined by users. Different users have different views and needs. Annotea should make it possible for any user group to define their own annotation types.’ (Kahana et al. 2002)	Allows annotating poems with text only.	‘Visual has shown that A successful language for many nonverbal vhildren are images audio (Kravits. Et al., 2002)	SENTPs using Amaya are well formed and structured as all poems are annotated according to the students.’ needs
6 The SENTP should be tested with different types of annotation tools (without building ontology) and (with building ontology) to compare and select one for pilot study.	Tested use of Amaya without building ontology.	‘Annotation Server’ (Cimiano et al., 2005, table 2)	OntoMat used by building SEN ontology with an open source OWL2 distributed as Protégé.	‘The framework itself was developed for the creation of ontology-based annotation in the context of the Semantic Web.’ (Gil et al., 2005)	The target of requirement six is achieved.
7 The SENTP should be easy to use and maintain and not expensive	Amaya was easy to use and maintain and is available free from the internet. WYSIWYG.	‘It also comes equipped with a ‘WYSIWYG style’ of interface which makes it easy to use’ (Amaya W3C, 2014; Dawod and Bell, 2011). ‘Amaya are free resources.’ (Ciravegna et al., 2002)	IT skills required for building the ontology and dealing with annotation process.	‘An annotation environment should be easy to use in order to be really useful. However, this objective is not easily achieved, because metadata creation involves intricate navigation of	Amaya is easier to utilize.

				semantic structures.' (Staab, Handschuh, 2002) 'without maintenance, annotations can easily become outdated. Therefore, unless annotation can be done cost-effectively the commercialfuture forthe technology is limited.' (Uren, et al., 2005)	
8 Accessibility: The staff should be able to access the SENTP anytime and anywhere even if there is no internet engine. Local (private) and remote (shared) annotations	Can access the SENTP using shared server or stand alone with Amaya.	'Annotation Server' (Cimiano et al., 2005, table 2) 'Amaya supports both local (private) and remote (shared) annotations.' (Kahana et al., 2002)	Can access through shared server.	'OntoMat Annotizer Annotation server, embedded in web page, separate file Annotation Server.' (Cimiano et al., 2005)	Amaya is easy to access from anywhere, even if there is no network, by installing the application as stand alone.
9 The process of annotation should follow simple steps so staff with limited IT skills can use it with few mistakes to avoid any disruption in the flow of the lesson.	Amaya was easy to use and maintain using a simple process for annotation without the need for building ontology or using complex Web language. The Web application is coded using HTML.	'It also comes equipped with a 'WYSIWYG style' of interface which makes it easy to use' (Amaya W3C, 2014; Dawod and Bell, 2011). 'Few organizations can employ professional annotators.' (Uren, V et al., 2005).	IT skills required for building the ontology and dealing with annotation process.	'It is obvious that an annotation environment should be easy to use in order to be really useful. However, this objective is not easily achieved, because metadata creation involves intricate navigation of semantic structures.' (Staab and Handschuh, 2002)	Amaya has simple process to annotate the text.

10 The SENTP should show the ability to enhance students' understanding of the topics.	We can get better student understanding using Amaya by increasing personal motivation and present the materials in different forms.	'Subject to personal motivation.'(Fensel and Morozova, 2010)	Can improve understanding to some extent	'Semi-automatic annotation tools rely on human intervention at some point in the annotation process. Annotations need to be reviewed to make sure it is annotation procedure is correct.' (El-ghobashy et al., 2014)	More effort is required for OntoMat.
11 The SENTP should show the ability to increase students' attention and concentration in the lesson.	Amaya can increase the students' concentration by presenting the teaching materials in different way, using different styles according to their needs.	'Use visuals to support written text' (Sobel and Knott, 2014) 'It's important to recognize that differentiated instruction isn't just for helping students with special needs – it's the best way to engage all learners.' (Brookes, 2012)	Can improve concentration to some extent	'It's important to recognize that differentiated instruction isn't just for helping students with special needs – it's the best way to engage all learners.' (Brooks, 2012)	Both can increase student concentration. However, Amaya present the teaching materials using different types of forms.
12 The SENTP should show the ability to increase student engagement and motivations in lessons.	Amaya can increase students' engagement by presenting the materials using different types of images for different levels and styles (from real environment or just images).	'Planning to motivate pupils and selecting and designing tasks involves not only a sound understanding of the material to be taught but also matching the level of work to that of the pupils.' (ATL, 2016)	Can improve student engagement to some extent	'Regular use of ICT across different beneficial motivational influence on students' learning.' (Becta ICT Research, 2003)	Both can increase student engagement. However, Amaya present the teaching materials using different types of forms.
13 The SENTP should show ability to reduce behavioural problems.	Amaya can offer clear, precise instructions that help to reduce behaviour problems.	'Recommendations to improve behaviour is to give clear, precise instructions.' (City of Bradford MDC, 2002)	Can reduce behaviour problems to some extent because it	OntoMat can offer clear, precise instructions which help to reduce behaviour problems.	Both can reduce behaviour problems with the use of annotation techniques.

			can present clear teaching material		
14 The SENTP should be able to support the teaching staff by reducing preparation time and providing support with class management and staff training	Amaya can reduce preparation time by offering different types of options and styles which are suited to different students' needs. However, the annotation process may be time consuming	'The manual annotation often results in a very high-quality metadata but is a very time consuming for the annotation process.' (Roy et al., 2010)	OntoMat can support the staff but requires effort and IT skills to make all the required resources available	Building ontology is a powerful way of semantic annotation, but hardly comprehensible by "normal users" (Fensel and Morozova, 2010)	Amaya is better in comparison with OntoMat Annotizer in supporting the staff.
15 The annotation process should be accurate	The Amaya annotation process is accurate	'A very accurate manner of annotating resources. Can support the needs of different users.' (El-ghobashy et al., 2014) 'The manual annotation often results in a very high-quality metadata.' (Roy et al., 2010)	Intermediate accuracy is found in OntoMat	Annotations need to be reviewed to make sure the annotation procedure is correct (Uren, et al. 2005) 'Semi-automatic annotation systems rely on human intervention at some point in the annotation process.' (Fensel and Morozova, 2010)	Amaya more accurate
16 The SENTP should replace or reduce the current manual methods	Amaya can replace or reduce the current manual methods	'Amaya can offer different forms of annotation such as text, image or audio.' (W3C, 2014)	Can reduce the current methods	'The annotation interface in OntoMat is used to annotate texts in a user-friendly manner.' (Ciravegna et al., 2002)	The SENTP may replace orreduce the use of current method

Table 4.7: Comparisons between Amaya and OntoMat-Annotizer

4.7 Summary

Despite the volume of existing studies in the field of the educational Semantic Web (Woukeu, et al., 2003; Aroyo and Dicheva 2004; Yang, et al., 2004; Devedzic, V., 2006; Gutierrez, 2008), there is little research on SEN education, and surprisingly little effort has been spent so far on developing the education of SEN using the Web. This chapter presents a novel method of using a semantic annotation tool to enhance SEN learning and support the teaching staff to facilitate SEN teaching. Various annotation tools are explored (Dawod and Bell, 2011) and two tools are selected to compare in an experiment: Amaya and OntoMat. For Amaya, all the annotations are added manually, which takes time, effort and associated staffing costs but little knowledge of IT skills is required from the users. In contrast, OntoMat-Annotizer used a 'drag and drop' method, which is quicker but requires sound IT skills. OntoMat relies on building an ontology (a means for sharing and standardising vocabulary), whereas Amaya has it hidden, which allow users with limited ICT skills (from the teaching staff) to use and maintain it easily. The results from the OntoMat annotation process saves designers and users time and effort, whereas Amaya takes more time to annotate but is more accurate, as presented in Table 4.7, Item 15. This comparison shows that although, Amaya provides some support for ontologies and OntoMat-Annotizer has full support for ontologies, the drawback from the OntoMat tool is that the authors must create and annotate the content, as stated by Handschuh and Staab (2002), and as seen from the experiment conducted in this research. This OntoMat annotation process is assumed to require domain skills and employs annotators with an associated extra cost which is in some cases is difficult. In addition, there is clearly a greater authoring effort in the use of Amaya as compared to OntoMat-Annotizer, nevertheless, it is regarded as requiring only simple IT skills and a set of simple instructions. Amaya is based on XML or HTML whereas; OntoMat-Annotizer is based on HTML only, which gives Amaya more flexibility in using different Web coding. Amaya is selected as the most appropriate tool to continue the pilot study. It is straight forward, freely available, can share different forms of annotation and easy to use interface with simple instructions.

Chapter 5: Pilot Study

Iteration II

'The man who removes a mountain begins by carrying away small stones.'

Chinese Proverb

5.1 Introduction

This chapter examines the impact of Semantic Web Annotation tool (Amaya) on enhancing educational performance in the teaching of SEN students. It presents a design of SEN teaching platform based on a Semantic Web Annotation tool (Amaya) coordinated with a web application. This design is evaluated by conducting pilot study in schools caring for special needs (SEN) students. Consequently, the motivations for promoting Semantic Web Annotation tools in the education of special needs students motivated the design of a new system that could support varied special needs students. The new system - SEN Teaching Platform (SENTP) - synthesises the core Web language for creating applications (HTML) and the Semantic Web Annotation Tool (Amaya). Concerning the SENTP design, a set of criteria are based on the previous chapter (chapter 4). This earlier experiment tested different annotation tools and selected of Amaya as a most suitable tool to conduct further work in schools. A major concern from this earlier study was to allow the SENTP model to consider the important factors and barriers that might influence Semantic Web annotation adoption. The identified criteria for a proposed SENTP focused on designing a teaching platform that is easy to use; supports/replaces the current manual teaching methods; coordinates with different abilities and requirements; and is available as required. The experimental content used in this study and implemented in the SENTP is poetry. Poetry is used in the design because it has certain qualities that make it an effective vehicle through which to teach SEN students. Poems that rhyme offer an excellent opportunity to listen for and find rhyming words (Dillon, 2016). However, it is one of the more difficult areas to understand for special needs students especially students with ASD (Punch, 1998), because poetry has a sizable vocabulary with underlying meanings that are especially difficult for autistic students (Gill et al., 2008).

Building on a comprehensive pilot study at two schools accommodating special needs students in the UK, nine interviews were conducted. All the data gathered from the two schools was thematically analysed.

The study follows a DSR approach composed of three phases. The first phase ‘Identify and build the SENTP’, is accomplished in three steps. Firstly, it started by identifying the problem area from the literature and the previous research (Communication Matters, 2012). Secondly, a vision is formulated and feasibility study undertaken that includes identifying the participants (teaching staff) requirements and understanding the special needs student requirements. Thirdly, preparing and scoping stage to design the SENTP. Designing SENTP include design an educational poetry website imported into Amaya. In the second phase, Semantic annotation was applied to poetry from the first phase. This process includes annotating all the poems with different types of annotations. The annotations included are the symbol systems currently used for special needs (Makaton, Widgit and Picture Exchange Communication System PECS), images, sound and information. The second phase involved conducting data collection and filtering. This process itself includes managing the required information which includes all the data gathered from the participant’s interview, class observations and field’s notes. All the data gathered is then thematically analysed. The last phase is evaluating the SENTP performance to see if it achieved the design targets/ criteria. The findings indicate that Semantic Web technology can benefit the education of special needs by utilizing Semantic Web annotation tools. The Semantic Web annotation tool (Amaya) has a considerable impact on enhancing such students’ educational performance and reducing the effort required from the teaching staff to design and prepare for each lesson.

The remainder of the chapter is organised as follows: Section 5.2 delivers the research design and output artefacts. Section 5.3 describes the artefact building and development (pilot study) in the targeted schools. Section 5.4 presents the SENTP model implementation. Section 5.5 presents the qualitative analysis, results and discussion. Section 5.6 presents the evaluation of SENTP. Section 5.7 summarises the chapter.

5.2 Design Research and Output Artefacts

The purpose of this Design Research iteration is to build actual, practical processes through which teaching staff benefit from the semantic annotation to develop their learning resources to achieve better learning understanding, engagement and reduce the preparation time. An extended framework involves new way of describing the language using the existing effective methods. As noted in chapter 4, semantic annotation could have a positive impact on the education of the SEN students as special needs pinpointed as needing urgent attention (Department for Education, 2013). Furthermore, Amaya have been selected as an annotation tool to conduct the pilot study. This chapter proposes a method for the annotating the special need teaching material. Also, it aims to further explore the user experiences and evaluate SENTP to identify the motiving factors for developing more common approaches to support SEN students and their teaching staff. Iteration two is designed and developed in two steps. Firstly, refine SENTP design according to the feedback from iteration one, and adjust the user requirements for iteration two accordingly. Secondly, explore the user experience through pilot study in real SEN domain. A pilot study is conducted to confirm the reliability and usability of the SENTP. Figure 5.1 illustrates the second iteration from the overall framework.

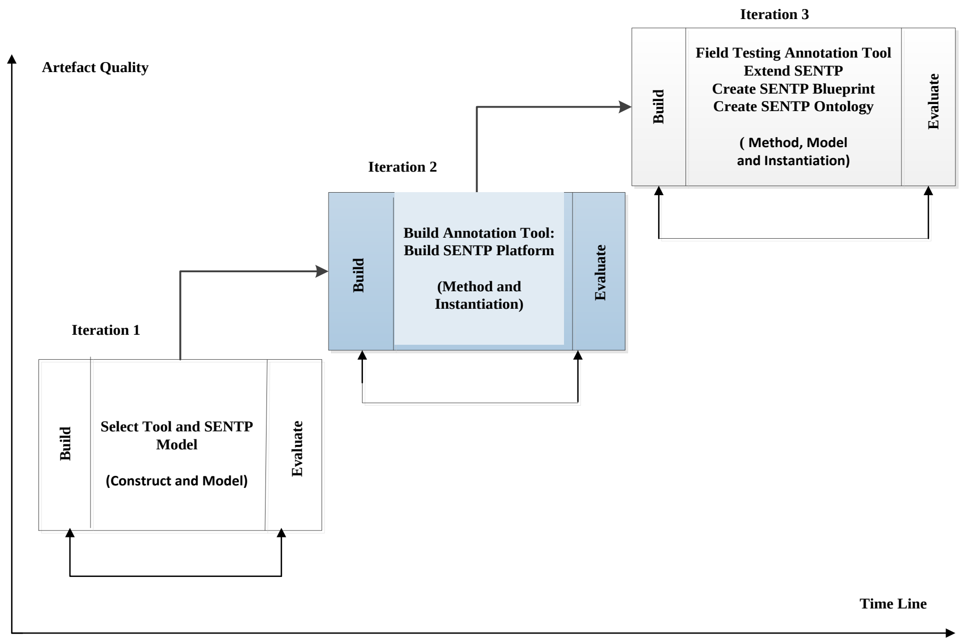


Figure 5.1: Research Iterations

5.2.1 Research Design and Platform Process

The study follows a design research approach through which learning of the problem space is accomplished through artefact evolvement and evaluation. Hevner et al., (2004) described the process as an effective solution to a problem. Effective solutions may not match with the optimum result. The effectiveness of the solution must be provable through an iterative evaluation of the design artefact(s). The artefact resulting from the Design Science Research (DSR) in this work was to induce the characterisation of the new SENTP model from observation of practice. The process that derives the discovery of the semantic web annotation technique to design SENTP is the refining and extending the structure of the website produced in (Dawod and Bell, 2011). The input for the first step is the poetry website and the output will be the refined poetry website, which will be the input for the second step. In the second step, manual annotation using Amaya will be conducted by the researcher, which produced the annotated poetry website. This website will be the input for the participant's requirement in order to modify the model according to the teachers' lesson requirements. This annotated website with the consideration of the participants' requirement will be input for the final step to produce the SENTP, as described in Table 5.1.

Steps	Method	Input artefact	Output artefact
1. Refine and extend the structure of the website	Build, amend and extend HTML website	Poetry website, Amaya, Mozilla browser, images, SEN symbols**(Construct)**	Improved HTML poetry website **(Model) and (Method) (Instantiation)**
2. Identify the text required for annotation/type of annotation	Manual annotation	Improved HTML Poetry website **(Model)and(Method) (Instantiation)**	Annotated text **(Method)**
3. Identify the teaching staff requirements to teach poems	Interview (Semi structured interview questions)	Annotated text **(Method)**	The teaching staff requirements for teaching poems **(SENTP Model)**
4. Develop and extend the SENTP model by incorporating the current symbol systems used to support SEN students and variety of SEN needs	Build Amaya Application	Web service artefact/ (**SENTP Model)**	Prototype application Extended SENTP **(Instantiation)**

Table 5.1: Iteration Steps – Input–Output Model

5.3 Artefact Building and Development (Pilot Study)

The experimental procedure outlined in chapter 4 yielded the tools and techniques selected to continue this research and shown the significance of using semantic annotation in developing special needs teaching material. This study was based on a comprehensive literature review and the results from the experiment conducted using two annotation tools, which then results in selecting Amaya to continue further work in this study. Symbol use in special schools is well established and widespread, with over 77% of schools indicating that they use them. Symbol use is particularly established in schools catering for pupils with severe learning difficulties, where the proportion using symbols is 96% (Abbott and Lucy, 2005; Detheridge and Detheridge, 2002). Thus, in this iteration, symbols are used to build new form of annotations within the design of the SENTP UI. A set of evaluation criteria for the proposed STP is developed in this chapter.

1. The platform model should be simple to use to make the platform model usable by staff with different IT skills and to avoid any technical problems.
2. The platform model should support the staff with the class management skills, including the ability to reduce behaviour problems and increase students' engagement level in class.
3. The SENTP model should be able to support/replace the manual methods as a huge effort required to prepare lessons.
4. The SENTP should include the symbol systems currently used for helping SEN in schools to assist with symbol systems training.
5. The platform model should support/replace the existing symbol cards existent.
6. The platform model should coordinate with different abilities and needs.
7. The platform model should improve the understanding of the poems, since poetry is one of the difficult topics to explain for SEN students.
8. The platform model should have flexibility to benefit in different subjects.
9. The platform model should increase the students' motivation and engagement in class.
10. The platform model should be easy to use, edit and maintain.
11. The platform model should offer different types of annotations (image, information, bigger text, sound and symbols).
12. The platform saved on the local server at this stage because some schools have no Internet in class.

5.3.1 The SENTP Framework

This section presents the building and development of a refined SENTP, as illustrated in Figure 5.2. Before initiating the design of the SENTP, it is necessary to understand the problem in its proper context and then understand the reasons for undertaking changes in the second version of the SENTP. These reasons define the key requirements for the new SENTP. Firstly, the second version of the SENTP will add the symbol systems, which form one of the main resources used currently in SEN schools, currently in cards form. Using visual support for the meaning of the words can help some children across many subject areas (Widgit, 2015). Secondly, the video and smaller font option are taken out; playing video during a lesson can take time to load and the smaller font is not necessarily adequate for SEN students. However, these items could be added if required by the teaching staff in the pilot study. Figure 5.2 illustrates the second version of the SENTP phases, steps and associated artefacts in Iteration 2. While designing the framework three phases are followed. Firstly, in Phase one identification and building SENTP is piloted. The SENTP model from Iteration one, with the findings, form the entry for the formulate vision and feasibility study step. Moreover, this phase includes defining a set of criteria for the extended Amaya. While, Phase two conducts data collection and filtering, which starts with annotating the poems with Amaya. The selection of poem annotation can change according to the participants' requirements. All the data gathered from the interviews are thematically analysed (Braun and Clarke, 2006). Finally, in Phase 3 the SENTP evaluation process is conducted, which is the last stage of Iteration two.

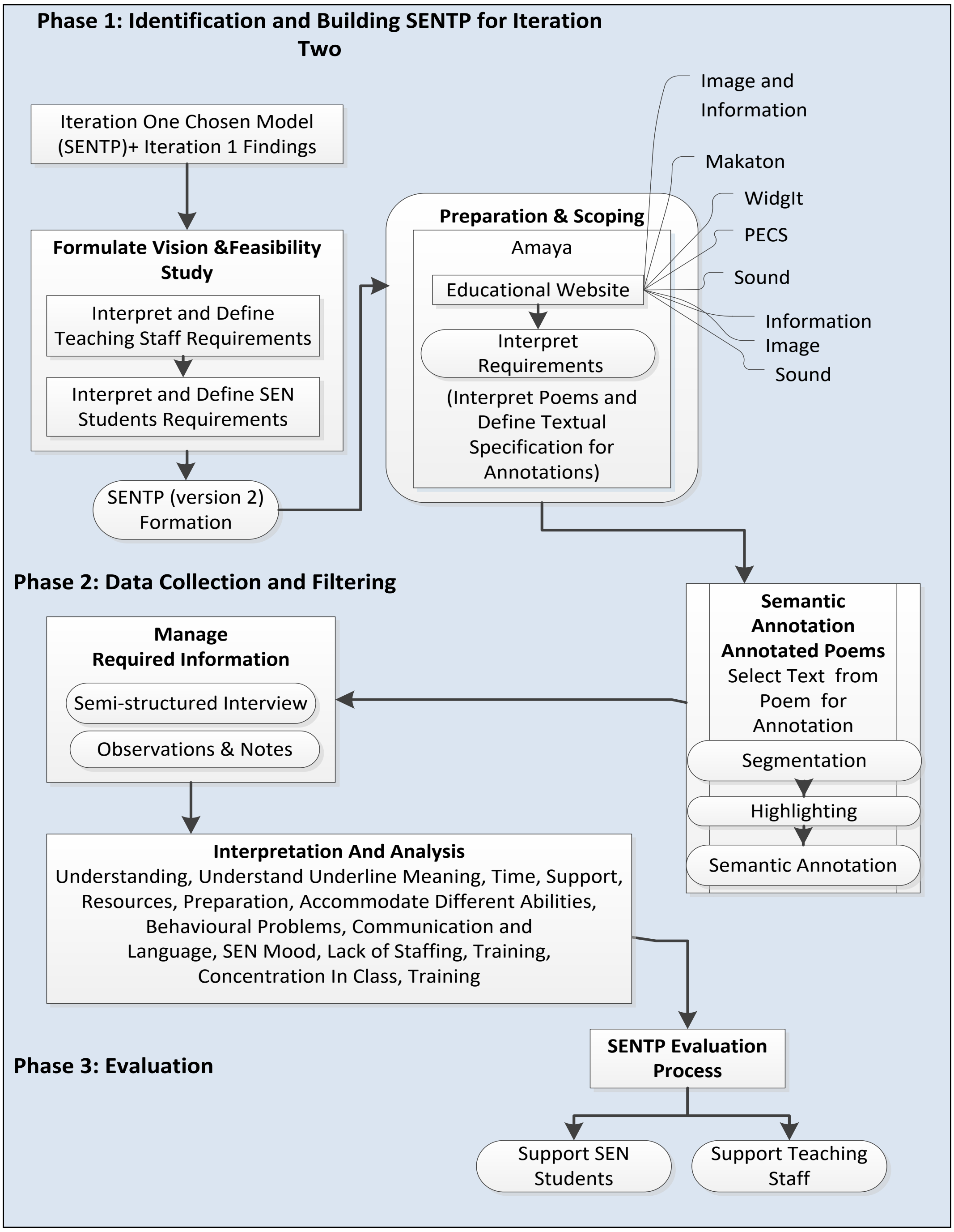


Figure 5.2: SENTP Framework in Iteration 2

5.4 Pilot Study and Data Collection

This section covers all activities to produce the platform assessment. The primary goal of data collection is to prepare data for assessing the SENTP model. The data used in this study was collected from February 2012 to October 2012. Qualitative method used to collect the data was through a series of semi-structured interviews. The interviews provide the opportunity to explore topics that cannot be directly observed from the participants' or the researcher's point of view (Patton, 1980; Marshall and Rossman, 1989). In this study, data collection activities are described as follows:

5.4.1 Participant Recruitments

Pilot study interviews were carried out in two schools in the UK, a pre-school with age range 2.5-5 years and a scondary special school with age range 11-19 years. Although, the research was targeted children school age range from 2.5-19, only the above two age sets are accepted to participate in the study. They sampled according to two categories: two Teachers and seven Teaching assistants. Out of twenty-five schools approached across different areas, two schools agreed to participate. The SENTP was demonstrated by the class teacher to a year 7 class at the special high school and by the researcher and some of the nursery staff at the pre-school. Demonstrating the SENTP in a class allows measuring the user's satisfaction of the SEN prototype interface as well as observing students' learning and their attitude. The interviews were conducted with nine participants. This sample size is efficient enough for testing the tool. This then confirmed by Virzi (1992) who reported that 90 per cent of problems can be identified with fewer than ten participants. Similarly, while Nielsen (2000) encourages researchers to use five participants for testing in a pilot study, he also claims that using more than ten does not necessarily result in the identification of further issues. Therefore, the selection size of nine participants should be sufficient for achieving consensus and study results targeted. Table 5.2 below illustrates the composition of the interviewee sample across the two schools.

Code	Sector	Class	Gender	Speciality	Training	Experience
Teachers						
T1	Special Needs High School	Year 7	Female	SEN	dealing with Autism in the classroom, BED (Behaviour Emotional Disorder)	All SEN (All Subjects)
T2	Pre-School	Nursery	Female	Manager/ Foundation Stage	No Training	Communication and Language
Teaching assistants						
TA1	Special Needs High School	Year 7	Female	SEN (HLTA - high level teaching assistant)	NVQ	All SEN (All Subjects)
TA2	Special Needs High School	Year 7	Female	SEN Key Worker	SENCO, NVQ	All SEN (All Subjects)
TA3	Special Needs High School	Year 7	Female	SEN	Remedial Teaching and Special Needs, Diploma in Teaching	All SEN (help with English and Maths)
TA4	Pre-School	Nursery	Female	Foundation Stage	General Training in SEN	Communication and Language
TA5	Pre-School	Nursery	Female	Foundation Stage		Communication and Language
TA6	Pre-School	Nursery	Female	Foundation Stage	SENCO	Communication and Language
TA7	Pre-School	Nursery	Female	SENCO Coordinator	SENCO	Communication and Language

Table 5.2: Participants' Description in the Pilot Study

Description	**Total**
Sample Size	9
Gender Female Male	 9 0
Age ranges of SEN children taught	(2.5–4), (11–19)
Preschool (2.5–4) Teacher Teaching Assistant	5 1 4
Secondary School (11–19) SEN Teacher Teaching Assistant	4 1 3

Table 5.3: Participants' Overall Description in the Pilot Study

5.5 Interview Preparation

5.5.1 Materials

A prototype was presented in schools on a laptop and a projector in a classroom. The sessions were recorded. A digital voice recorder Olympus VN-8600PC was used along with a small notebook and a pen for extra notes.

5.5.2 Security

Anonymity is a crucial concept in social research in general, and in qualitative research in particular (Mayers, 2013). All the interviews were managed by the researcher using the interview framework. All recordings were transferred onto a personal laptop and two USB drives secured with a password known only to the researcher. Tilley and Woodthorpe (2011) highlight the significance of confidentiality in minimising the risk of harm to participants.

5.5.3 Research instruments

The main research instruments are the interview question framework for the teachers and teaching assistant (see appendix D), and the website supported by Amaya software. The questions were direct and open-ended to allow the participants to be more engaged during the interview and to describe their experiences (Crowe, Inder and Porter, 2015). The learning website was designed using HTML and supported by using Amaya. It concentrates on learning poems as a sample of learning materials. The NVivo10 software package was employed to carry out thorough and reliable qualitative data analysis. It is a very reliable management tool that can assist in analysing the data (Welsh, 2002).

5.5.4 Data Sources

Following ethical approval given by the university (see Appendix B for the interview agenda evidence), twenty-five schools caring for SEN students were approached via email, telephone and the postal system. Twenty-five covering letters were sent, along with an information sheet, which was required by some schools. However, only two schools agreed to participate in the research. This highlights the difficulty in gaining access and permission to carry out research within SEN domain due to ethical reasons, limited staff time and willingness to participate in research.

The data was collected over a six-month period due in part to the scheduling and timing pressures within a typical school. For example, the nursery opens only for two and a half hours. Furthermore, the SEN teachers needed to take into account that a change of routine may affect some of SEN students, particularly autistic children. Finally, the difficulty of finding cover for the duration of the interviews with the staff members had to be overcome. In total, nine interviews were conducted, as explained in Section 5.3.3, which will be thematically analysed. The selected schools each had different teaching environments, student's educational styles, age range and backgrounds. The first school is a special needs high school cares for 150 students with an age range of between 11 and 19 years. The second is a pre-school that supervises 18 children with an age range of between 2.5 to 4 years. The nursery supports children with learning difficulties and/or disabilities and with English as an additional language.

One of the theoretical challenges was in determining whether to conduct individual or group interviews. Group interviews was difficult due to time constrains of the teaching staff. Hence, this research arrange individual interviews as each individual has their own experience and views and the staff can arrange the most suitable times for the interviews. All interviews were conducted after a short demonstration of the prototype that followed a briefing session with the headteacher determining the suitability of the SENTP to each school specific need. The interview questions were designed to be timely (able to be answered within the time allowed) and focused. The interviews were typically of one hour reduced with some of the staff to 30-minute duration, in consideration of time restrictions. (See Appendix D for the interview questions framework). Some questions were intended to gain knowledge about participant background and experience and to determine their expectation. Extra time at the end of the meetings was made available for participants to discuss any further ideas or recommendations. The data was also collected from school visits, observing the students in class with SEN teaching. Figure 5.3 shows the architecture of pilot study model, which is considered when designing the interview questions.

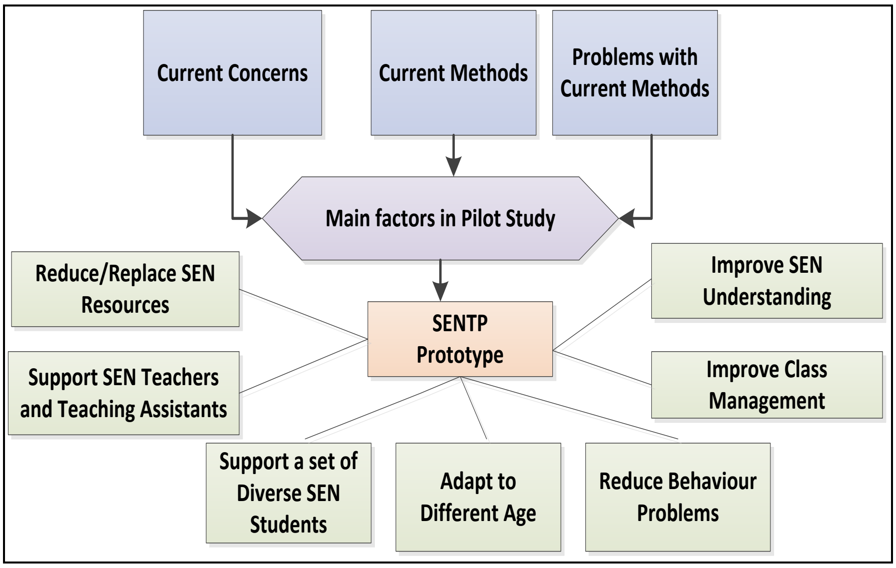


Figure 5.3: Pilot Study Model

5.5.5 The Procedure of the Pilot Study

In the SEN high school, the interviews were conducted with the year 7 teacher and three teaching assistants. Whereas, the pre-schools' manager arranged for a meeting with all the staff to check the applicability of using SENTP with their children group.

The research details were explained to each participant, and an informed **consent form** provided for the participant to sign and give permission to conduct the interview. Furthermore, an **information sheet** with full details about the research being conducted was given to each participant. The participants were told that they are free to withdraw from the study at any point, without having to give a reason why. All the arrangements regarding confidentiality of data were explained clearly before the interviews. The process gave participants some idea of what to expect from the interview, gains a level of trust, and is a fundamental aspect of the informed consent process (See Appendix B). All interviews were recorded (see Appendix E).

The SENTP was demonstrated in the special school by year 7 class teacher, However the researcher participates with the teaching assistants in teaching one-to-one to complete the assesement worksheet. Whereas, the pre-school manager suggested a group of five children for demonstration accompanied by an experience mumber of the teaching staff (teaching assistant) due to time restrictions and staff shortages. The content annotation process starts by preparing a consent form, ethical approval, and the researcher criminal records bureau (CRB) checks. Headteachers were contacted via telephone, post, and email. The headteacher or the staff member responsible for agreeing to participate in the research decided if the demonstrations were to be given in a focus group with teaching staff or to students in class. Teachers from participating classes selected a convenient poem and made editing suggestions if needed.

5.6 Annotating Educational Content

Semantic annotation (using Amaya) underpins all the educational content in this study. First, the class teacher selects the type of annotation, the style of the poem, then the poem appropriate for the class demonstration. The poetry teaching materials that is used for this research, chosen from the national curriculum (National Curriculum, 2014). The platform is prepared beforehand with the kind of annotation required (e.g Images or Makaton Symbols). The annotation options are wide-ranging, depending on the SEN age and needs. In this study, the nursery school teacher selected 'The Zoo' poem without alteration of the SENTP user interface (UI). Then, the secondary class teacher chose 'Bedtime' poem with symbol annotation form for class demonstration and image annotation form for one-to-one assessement.

Figure 5.4 presents the poetry webpage with different annotation options. Figure 5.5 depicts the poetry webpage with range of styles and age. Figure 5.6 presents the children webpage with various types of children poems which can be adapted according to the lesson, teaching staff and students' requirements.

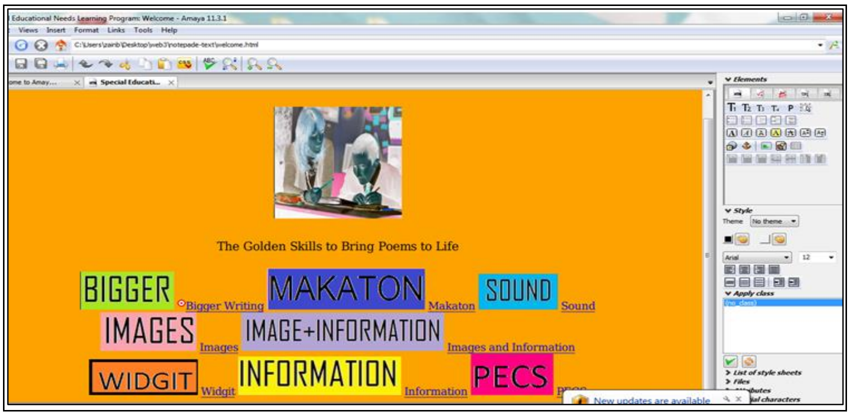


Figure 5.4: SENTP User Interface –Main Page

Figure 5.5: Web Page with Various Styles of Poems – Page 2

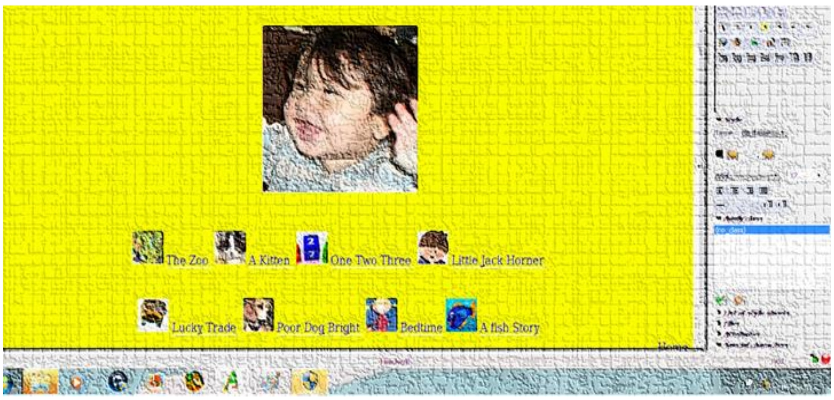


Figure 5.6: Children Poems Home Page

Figure 5.7 shows a screen capture of Amaya with the annotation created on the 'Bedtime' poem. 'Bedtime' poem was tested in the special secondary school as part of the teaching demonstration for the whole class, with Makaton as an annotation and images for the one-to-one sessions. Table 5.4 shows a screen capture of different annotation parts with Amaya showing Makaton symbols.

Figure 5.7: Amaya Annotation Interface Showing the 'Bedtime' Poem

Text	Description
I	Title: Annotation of Bedtime Author: zainb Source document: Bedtime Annotation type: Comment Created: 2013-08-18T23:17:54+00:00 Last modified: 2013-09-22T11:25:32+00:00 I 
go	Title: Annotation of Bedtime Author: zainb Source document: Bedtime Annotation type: Comment Created: 2013-08-18T21:55:52+00:00 Last modified: 2013-09-22T11:25:53+00:00 go 
a	Title: Annotation of Bedtime Author: zainb Source document: Bedtime Annotation type: Comment Created: 2013-08-19T10:39:39+00:00 Last modified: 2013-09-22T11:27:49+00:00 a 
bed	Title: Annotation of Bedtime Author: zainb Source document: Bedtime Annotation type: Comment Created: 2013-08-18T21:51:15+00:00 Last modified: 2013-09-22T11:26:42+00:00 Bed 

Table 5.4: Different Annotation Parts with Amaya Showing Makaton Symbol

When the teacher clicks on the pen mark, as illustrated in Figure 5.8, the screen shows the image of each word as presented in Figure 5.9.

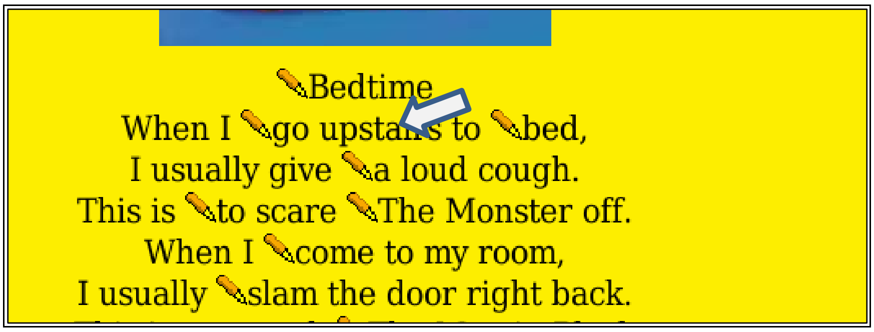


Figure 5.8: Screenshot of Amaya Annotation Indicated by a 'Pencil'

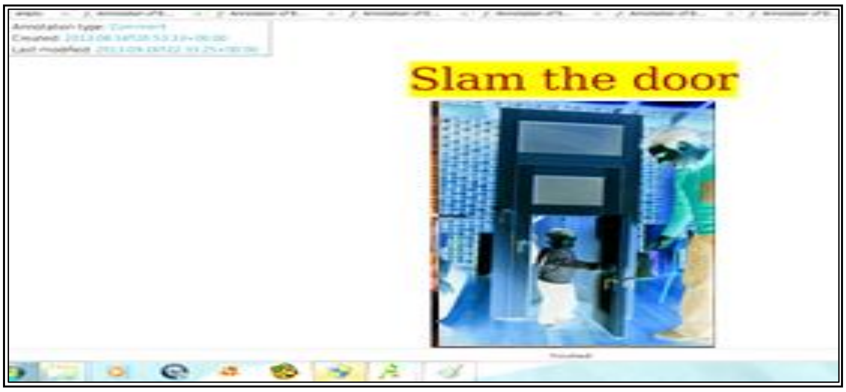


Figure 5.9: Screenshot of Annotating 'Slam the door' from 'Bedtime' Poem

'The Zoo' poem tested in the pre-school caring for special educational needs. Figure 5.10 depicts an annotation with an image ('White Polar Bear') and Figure 5.11 depicts another annotation with an image option ('Trunk'). (See Appendix C for the rest of the evidence)

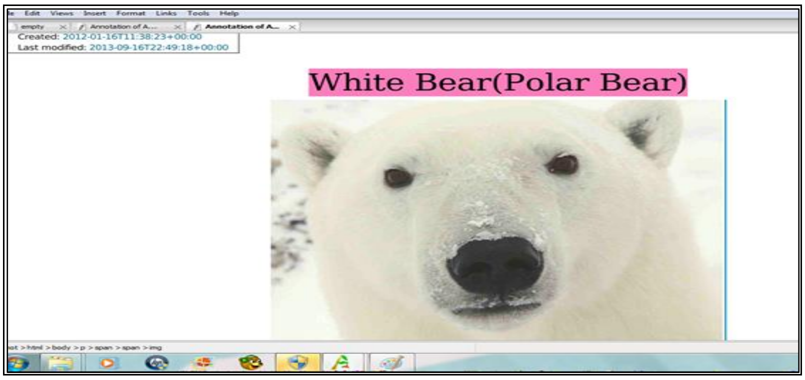


Figure 5.10: The Screenshot Annotating ‘White Bear’ with Image

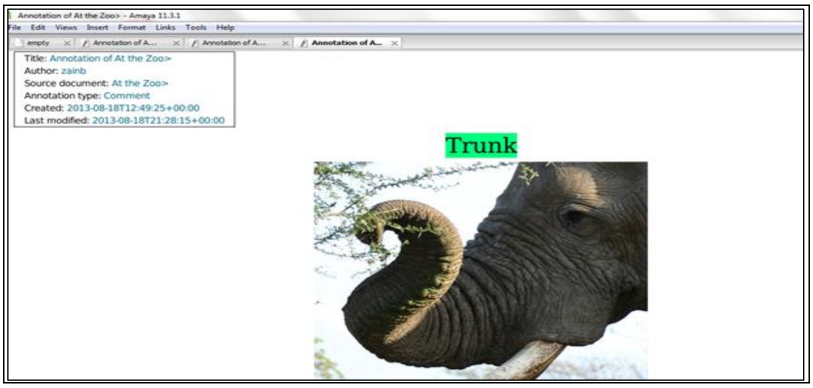


Figure 5.11: Screenshot Depicts Annotating ‘Trunk’ with Image

5.7 Analysis, Results and Discussion

In this study, the data collected was thematically analysed. The results were grouped into common themes in the following sections to facilitate comparison between the categories. Table 5.5 depicts the comparison between the categories.

5.7.1 Adopting Thematic Analysis as a Research Approach

The practical purpose of this analysis is to confirm and evaluate the SENTP design with Amaya annotation tool technology. Step one in developing the analysis plan for this research is to be familiarised with the data. Data familiarisation through the transcription process, by listening to the interviews and reading through the data, while thinking about possible themes (Braun and Clarke, 2006). Thereafter, first codes generated from the transcript information (Braun and Clarke, 2013). Qualitative data analysis software NVivo10, used to facilitate the thematic analysis in the pilot study.

All the data exported to NVivo10, which coded the interesting features of the entire dataset, as illustrated in Figure 5.12. Additionally, identify themes and review them. Each theme captures something important about the data in relation to research questions. All the data relevant to each theme is extracted to ensure all the relevant data are connected first with individual codes and then with the theme. This process will build a framework of themes to show the connections and relationships between themes and subthemes (Braun and Clarke, 2006). Table 5.5 outlines the eight codes, themes and sub-themes along with the number of times each theme and sub-theme was mentioned by the participants.

Figure 5.12: The Key Codes of the Participants' Interviews

Codes	Themes	Sub-Themes	Definition
Current Teaching Methods	-Manual Methods (93), Computer programs/ Internet (9), Time Consuming (5), Preparation Demands (4), Visual (5), Required Individual Support (9) and Required More Staff (1)	- Computer Programmes (4), Internet (4), Visual using Images (18), Symbol Systems (6), Designed Booklet (5) and Document Created (1)	What is the scope of study? Explore the current teaching methods used in schools for SEN
Understanding Current Teaching Requirement	-Support Teaching Staff, Understanding (5), Resources (42), Time (9), Support (2), Visual, Class Management, Staffing (2), Communication and Language (2), Personal Social and Emotional (2), ASD and Learning Progress (2)	-Understand Underlying Meaning (9), SEN Understanding Poems (5), Behavioural Problems (9), Concentration (1), Time Demand (9), Preparation (6), Accommodate Different Abilities (2), Reading (4), Numeracy (1), Writing (1), Communication (3), Engaging (2), SEN Mood (4), Lack of Staff (5), Training (6), Organization (4), English as a Second Language (1), Support ASD (2) and Concentration (1)	Understand the current teaching needs and what they require Manage and interpret the SEN and teaching staff requirements
Important Teaching Factors for SEN in School	-Resources (9), Class Management (9), Understanding (8), Group Size (One-to-One or Small Group) (9), Personal Social and Emotional (5)	- Concentration (1), Understand Underline Meaning (1), Differentiation (1), Routine (1), Visual (5), Time Management (1), Prepared (1), Engaging (2), Demonstration Layout (5), Working in Small Groups or One-to-One (5), Resource Layout (2), Mood (4), Concentration (1), Poems (7), Simple and Short Poems (2) and Language (3)	Categorise the demands based on requirements, Manage and interpret the SEN students' requirements
Poems	- Importance (2), Support (1) and Difficult (6)	-Essential for Pre-School (1), Support SEN Students in Teaching and Learning (2), Supports with Talk (1), Can Teach All Subject in Pre-School (2) and Difficult to Explain the Underlying Meaning (2)	Categorise the demands
ASD	-Resources (8), Class Management (2), Understanding (2)	- Concentration (1), Understand Underline Meaning (2), Routine (2), Visual (4), Prepared (2), Inviting user interface (2), Management (2), Understanding difficulty (2), Behaviour (1)	Categorise the demands and Manage and interpret the ASD requirements

Codes	Themes	Sub-Themes	Definition
The Use of Semantic Web Annotation Tool (SEN Teaching Prototype)	-Aid All Types of SEN (9), Preparation (3), Class Management (16), Resources, Setting (SEN Mood), Teaching, ASD (4), Concentration (2), Learning Process (150), Availability (1) and Support (6)	–Reduce Pressure on Teaching Staff (10), Support Teaching Staff (5), Save Preparation Time (7), Support with Preparation (5), Help with Staffing Problems (Lack of Staff) (4), Support for Autistic (ASD) Children (5), Accommodate Different Abilities (16), Support/Replace Resources (11), Replace Cards (1), Support/Replace Resources (6), Reduce Behavioural Problems (7), Better Mood, Support with Reading,, Differentiate Numeracy, Can Be Used for Different Subject (25), Can Support ASD (12), Effective Learning (216), Writing (2), Useful in Teaching Poems (7), Motivation (11), Engaging (1), Better Concentration (2), Better Teaching Results (4), Understanding (6)	Undertake pilot research and evaluate SEN prototype in schools
Evaluation	-Layout (8), Content (9), Participants suggestions for Future Work	-Bright Colours (4), Suitable Font and Colour (4), Images (1), Bigger Images (4), Use Real Pictures (1), Adapted to younger Age (9), Adapted to be used by SEN Independently (2), Special Version for Teachers (1), Can be used for Different Subjects such as Maths (1), Popular Characters within the Prototype (1), Small Text (2), Short Rhymes (2), To have a Choice of Annotate Words or Lines (7), Use Different Languages for Annotation (1), Choose to use SENTP in Future (9)	Evaluate SEN prototype if it supports the teaching staff and enhance the teaching and learning of poems in class

Table 5.5: Open-Coding Concepts Categorisation

Current Teaching Method: During the interviews, participants identified various ways of teaching poems which is either using the computer or a manual way. Figure 5.13 summarises the findings from the participants' interviews, highlighting different methods used to teach SEN students, depending on their difficulties. Figure 5.14 illustrates the various manual existing methods used to teach SEN students. The theme for current teaching method among these categories is labelled Current Teaching Methods. The observation shows that using images is the method that all participants use in their teaching. Moreover, from reviewing the participant's interviews it shows that current teaching methods requires time, preparation, and it should be visual, as indicated in Figure 5.15. The participants signposted the current teaching requirements during the interviews by expressing their current concerns, current issues and the main issues in teaching SEN students. The theme for the requirements is labelled understanding current teaching requirement.

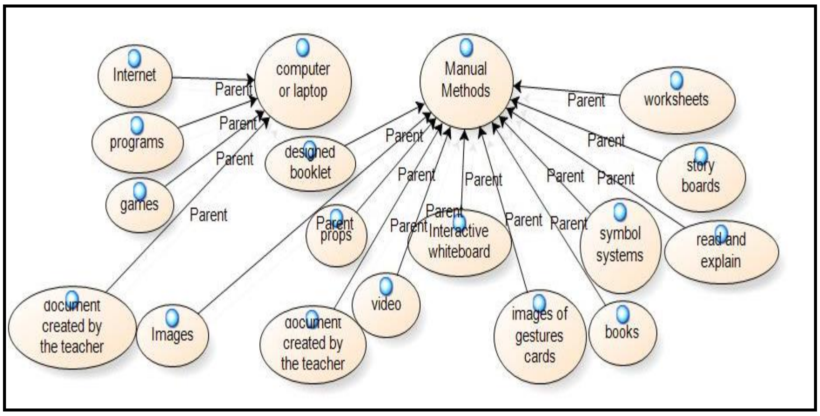
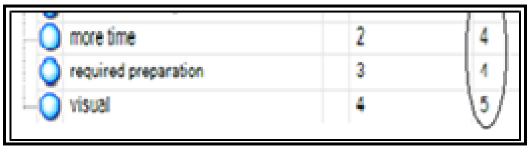


Figure 5.13: Results of the Current Teaching Methods Description

Manual Methods	9	86
books	3	6
designed booklet	3	5
document created by the teacher	1	1
Images	8	18
images of gestures cards	1	1
Interactive whiteboard	2	5
props	4	8
read and explain	3	7
story boards	2	4
symbol systems	2	6
video	2	4
worksheets	2	4

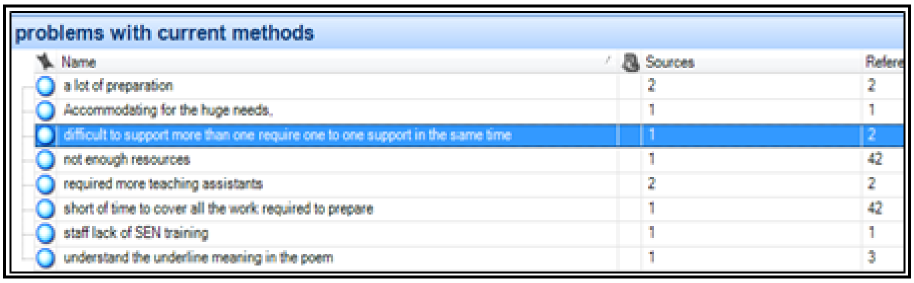
Figure 5.14: Manual Teaching Methods



more time	2	4
required preparation	3	4
visual	4	5

Figure 5.15: Results Depicts the Main Concerns of the Teaching Staff

The participants' descriptions of the main problems being faced with the current SEN teaching methods include the preparation of the resources required and accommodating considerable needs differences. Consequently, the findings from the observation were that supporting more than one SEN at a time in many cases requires one-to-one support. However, staffing was expressed as a common problem, as identified by the participants in Figure 5.16. Another problem expressed by the teaching staff was lack of SEN training. Hence, understanding the poem's underlying meaning was clearly pinpointed by many participants, expressing their special concerns in teaching ASD students. Figure 5.16 outlines the problems being faced with the current teaching methods.



problems with current methods

Name	Sources	Refere
a lot of preparation	2	2
Accommodating for the huge needs.	1	1
difficult to support more than one require one to one support in the same time	1	2
not enough resources	1	42
required more teaching assistants	2	2
short of time to cover all the work required to prepare	1	42
staff lack of SEN training	1	1
understand the underline meaning in the poem	1	3

Figure 5.16: Problems with Current Methods

Understanding Current Teaching Requirement: Gathering feedback from different environments such as nursery and secondary special school for SEN improved the understanding of the problem. Figure 5.17 summarises the findings from the teaching staff regarding their teaching concerns. The theme for the requirements is labelled 'Understanding Current Teaching Requirement'.

Current concern

Name	Sources	References	Created On
accomodate different abilities	1	2	10/12/2012
behavioural problems	4	6	28/11/2012
can not read	0	0	07/10/2014
communication and language	2	2	08/01/2013
concentration	1	1	07/10/2014
engaging them	2	2	10/10/2014
funding	1	1	13/12/2012
lack of staffing	1	3	10/12/2012
learning progress	2	2	21/12/2012
more staff required	2	4	10/10/2014
organization	2	3	28/11/2012
personal social and emotional	1	2	08/01/2013
preparation	3	4	28/11/2012
progress	0	0	07/10/2014
resources	1	2	11/12/2012
SEN mood	2	4	11/12/2012
SEN Numercay	1	1	13/12/2012
SEN reading	2	2	13/12/2012
support	1	1	10/12/2012
time	5	9	28/11/2012
training	2	4	10/12/2012
understand underline meaning	1	9	10/12/2012
understaning	2	4	13/12/2012
writing	1	1	10/10/2014

Major issue

Name	Sources	Re
absorption	2	3
ASD	2	2
behaviour	2	3
communication	1	1
lack of staffing	1	1
preparation	2	3
SEN reading	1	2
training	2	5
understanding	1	3

current issues

Name	Sources	References	Created On
different way of learning	1	4	10/12/2012
English as a second language	1	1	20/01/2013
mood of the students	1	1	10/12/2012
preparing resources	1	1	09/10/2014
understand what they read	1	1	19/01/2013
working in different tasks	1	1	10/12/2012

Figure 5.17: The Teaching Staff Concerns and Issues while Teaching SEN

The key issues observed from the participants were behaviour problems, time, preparation and the underline meaning, in addition to other concerns such as staffing and understanding. Therefore, the need for different ways of learning to increase understanding and to improve SEN mood was expressed by most of the participants. Finally, most of the participants pinpointed ASD as a major issue required significant effort to manage in SEN class.

Important Teaching Factors for SEN in School: It was observed through the interviews that the participants felt that children with autisim are one of the main factors required attention in SEN schools. Another observation was the change faced by the teaching staff with an autistic child who has a short concentration time, difficult to understand underline meaning and can work in small groups. Moreover, they find engaging students, time management and use of visual resources for teaching are important, in addition to other factors as illustrated in Figure 5.18.

important factors for SEN

Name	Sources	Re
ASD	2	3
difficult to concentrate for long time	1	1
understand underline meaning	1	1
working in group	1	1
background	1	1
colour	1	2
concentration	1	1
differentiate	1	1
engage the students	2	3
font	1	1
join a group during the learning process	1	2
make things lively	1	1
mood	2	4
poem	2	2
choosing the right poem according to their ability	1	1
routine	1	1
socialising	1	1
structure	1	1
they like structured routine	1	2
time management	1	1
to be prepared	1	1
to direct them in specific part in the poem	1	1
understanding	1	1
visual	5	5
pictures	3	3
words as virbal communication	1	1
working in one to one	2	2
working in small group	3	8

Figure 5.18: Results from the Interviews Depicts the Important Factors for SEN

Poems: Most of the observations from the participants pinpointed the significance of using poems as a tool for teaching different subjects for SEN students, as illustrated in Figure 5.19.

Poem or Rhymes

Name	Sources	Re
can teach all subjects in pre school	1	2
helps with SEN students teaching and learning	2	2
helps with talk	1	1
SEN students finds it difficult to understand especially ASD	1	2
some poems takes more time to explain	1	1
very important for pre school	1	1

Figure 5.19: Results Depicts the Use of Poems in Teaching SEN

Autistic students (ASD): Some participants flagged ASD as a major issue that required management, which was clarified from observing participants' experiences in Figure 5.20. The participants expressed the difficulty of SEN students to concentrate for long periods of time, and to understand underline meanings. Furthermore, the participants highlighted the necessity to teach ASD SEN students in small groups.

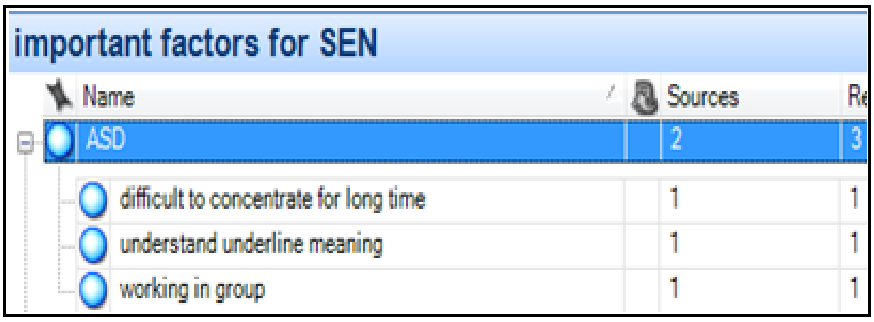


Figure 5.20: Coding Depicts ASD as one of the Significant SEN Issues

The Use of a Semantic Web Annotation Tool (SENTP): The interviews reflected on the suitability of using SENTP in teaching poems to SEN students. The observation made from the group demonstration and one-to-one support during assessments with worksheets. The results of evaluating the SENTP are summarised in Figure 5.21. The interviews indicated that it was appropriate that a SEN prototype be built to support the teaching staff and enhance their teaching of SEN students. The findings show that most of the participants believe that the SENTP can support the current teaching methods. However, one observation made during the interviews was that the SENTP can replace the manual methods. Moreover, it can improve class management by increasing students' engagement because there was more interaction between the students and the teachers and the students' body language which is picked from class observation. Also, simplifying the work by adding different symbol and images to support the teaching material and this is picked from the one-to-one assessement using the SENTP with image annotation form. Moreover, allowing differentiation in class which was clear during the class demonstration at two schools with group of different special need issues. Furthermore, SENTP increase students' motivation which was clear from the student interaction in class at the two schools, the student remembered the poem in the second visit as confirmed by the TA1, *'the students answered the questions, completed the tasks and asked for more work'*. T1 confirmed the impact of the SENTP on increasing student motivation and engagement for a student with multiple disabilities who never shares any class demonstration as follows:

'Absolutely, because someone like [student name] who doesn't maintain eye contact with the interactive whiteboard. struggle to look at the board for a long period of time, this absolutely catches their attention, I think it does work because when they look up if they can't access the word they can access the pictures. Definitely'

In addition, the SENTP can support the teaching staff as it shows that most of the participants believed that the SENTP provided time savings, aided preparation, reduced the workload on staff and reduced the pressure on staff. Moreover, the SENTP can help with staffing, which is one of the important points. T1 responded with comment on the use of the SENTP in group work to reduce the staff shortages:

'I think a lot, because then for example with all the autistic pupils in my class, they can be grouped and then obviously, watch it together they don't need one-to-one support and my teaching assistants would be freed up to help somebody else'.

Most of the participants believed that the SENTP can improve understanding, support ASD, support short term memory and can be useful in all subjects and for different types of abilities. TA1 responded to show that SENTP can improve the students' understanding and support their short memory.

'Well yes, because like I said they remembered it [SENTP demonstration], didn't they? I mean we've done certain poems in the past and a lot of them they don't remember but today they did. They remembered exactly what we did, they remembered the name, ..., what you did.'

The SENTP is a useful tool to teach poems because it offers efficiency in the lesson and can be available any time. Finally, all participants expressed their willing to choose the SENTP in future lessons.

SEN Prototype

Name	Sources	Refe
useful	7	25
used in different subjects	1	1
TA	1	2
symbol systems are useful with SEN prototype	2	3
support manual methods	5	6
support	2	4
successful way to engaging students in class	1	1
successful	1	1
simplify the work	1	3
save time	1	7
running the session smoothly	7	7
results	3	7
Resources	4	5
replace the cards	1	1
Reduce workload	2	2
Reduce staff required	1	2
Reduce preparation	2	3
Reduce behavioural Problems	4	4
pressure	2	3
poem is successful with SEN prototype	1	2
Participants suggestion	0	0
offer differentiation	3	5
not sure	0	0
interesting	2	2
Increase motivation	6	6
Improves the educational progress	4	4
Image Card System	2	2
helps with lack of staffing problem	2	2
help with inexperience staff	2	2
Grade	2	2
Good Tool	1	1
efficient lesson	1	1
Design	2	3
choose to use it in future	8	13
Better understanding	2	5
Better learning for SEN	8	150
better concentration	1	2
Better class management	4	6
Better achievement	2	3
Available any time required	1	1
ASD	3	4
aid short memory	0	0
Aid all types of SEN students	4	8
all SEN students	4	7

Figure 5.21: Results of Coding from Nvivo Depicts the SENTP Evaluation

Evaluation: The final theme is that of evaluating the SEN prototype, which is labelled 'Evaluation'. Although all participants found the SENTP a useful resource for enhancing SEN education, there are some participant recommendations to improve the design of the SENTP. These recommendations are illustrated in Figure 5.22, following.

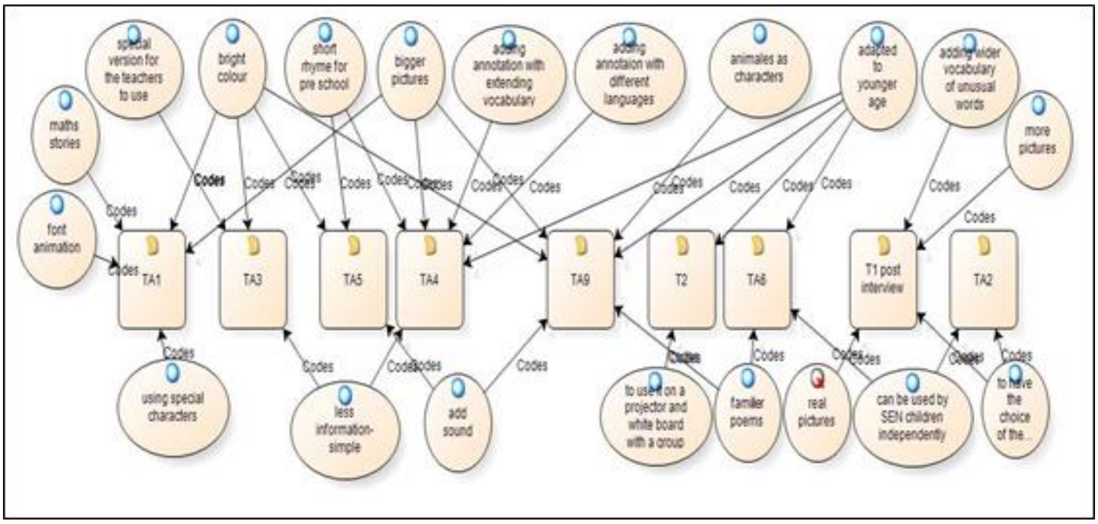


Figure 5.22: Participants' Recommendations to Develop SENTP

The participants suggested some refinement in the layout of the user interface, such as font, colours and more images and wider vocabulary. Font, colour and image are important factor for younger as as the pre-school chidren who are 2.5 to 5 years would be more interested in child friendly user interface as described by TA6 *'I think it would be nice if it is more child friendly [..] especially consider our children 2.5 to 3 and a half'*. The staff believes that SENTP is a good tool to explain unusual words which is difficult to understand and support the current methods as some words not included in a symbol card set as suggested by T1 at the special school 'to include a wider vocabulary [….] do you remember that we came across some words not having a picture'. Furthermore, SENTP can be adapted to different subjects such as Maths as noted by T1 *'I think in RE would be very valuable resource to use as an example, obviously other subjects, and in history and geography'*. Additionally, some participants suggested changing the user interface for the students to work independently. The participants suggested that adding annotation in different languages, as requested by the teacher, can support teaching younger ages for children speaking languages other than English as expressed by TA5 *'I mean it will help with children with English as a second language that don't always understand what the* *nursery rhyme is about. They may sing along with it because they hear the other childrens but by using the images alongside the nursery rhymes they can pick it up'*. Moreover, the teaching staff suggested that SENTP can be useful for younger age as many special need students mentally much younger than their real age as noted by TA5 from the pre-school 'the only thing I can say is that if it would be adapted to a younger age'. (See Appendix F for more evidence)

5.7.2 Results and Discussion

The observations from all participants' interviews were analysed, using NVivo software to search for the most frequent words, which highlighted understanding, communication, and preparation as important aspects in teaching SEN. The findings are summarised in Figure 5.23.

Figure 5.23: Results from the Interviews of Performing Word Frequency

Several principal themes were developed during coding through the links among categories. Moreover, the interview observation of the main points discussed during the interviews, which have a significant impact on SEN teaching and learning. The results from the coding outlines the scope of the research that was pinpointed main themes required to achieve for the new SENTP design. Table 5.6 presents nine themes assigned to the categories of dimension one: SEN students and teaching staff interaction.

Category	Theme
Communication	1. Engaging 2. Concentration 3.Behaviour problems
Understanding	1. Understand underlying meaning 2. Accommodate different abilities 3.Visual resources
Preparation	1. Management 2. Resource availability 3. Staff training

Table 5.6: Conceptual Framework outlining the Main Themes

Communication: Theme one, **Engaging**, was one that secured agreement from all nine interviewees that engagement would improve the level of understanding as reported by TA6: *'…It is nice to have different ways telling stories. just different way of engaging their attention'.* Also, it is a good engaging tool for the students who is interested in working with the computer as described by TA4: *'It may be to engage children whose got so much interest [..], it can be way of engaging them because they might like the visual and the sound and it might be something they are familiar with'*

Concentration is another theme which effect of improving the interaction in class and accomplish better understanding results as stressed by TA6 '*The interesting thing is that it hold their attention for long period of time'*.

Behaviour problems, was one that secured agreement from eight interviewees that behaviour problem is one of the main concerns for the teaching staff because it affects class activities and on improving student communication. TA1 stressed this point: *'Obviously behavioural of certain students because if one student not doing what he supposed doing, it has effect on the rest of the class'*. Also, TA5 reported the importance

Understanding: Theme one gained shared agreement from the participants on **understands underline words** especially with poems. The teacher from the special school expressed the difficulty of Autistic students to understand the underline words as follows;

T1: *'They understand it face value as it is literal not the underlying meaning of what the authors trying to get out, that is quite difficult for them to understand' 'To understand the underline meaning in the poem, so with some of our ASD pupil they would understand what they read as literal'.* TA6 point out that understanding is important to develop the SENTP and need to be tested within wider data *'we have to practice it and evaluate it […] at this moment in time I wouldn't know if it would be better to use it or not until we have done it for some time'*. Furthermore, understanding what they learn is one of the main concerns for many participants such as TA4' the concern that you want the child to progress, really and to learn'

Theme two shows the significance of **accommodating different abilities** in class. The general opinion was that the teaching resources should benefit all types of abilities as reported by TA4 *'if you did some of the changes and it was tailored at our age group'.*

Theme three expressed strong opinion of all the participants that SEN students understanding required **visual resources.** They use different types of visual teaching methods such as symbol cards, images prepared by the teaching staff, and sticky pictures which was noted by TA4 *'if the children can't say I want a particular thing then the booklet would help'.* Also, T1 stressed the importance of having visual resources *'Which of the above you consider more important for this type of support? 'Visuals [...] images [...] visuals [...] visual images'.*

Preparation: Theme one in the preparation category was **management** which is raised as main issue by all the participants. The teachers expressed their needs for staffing, time and resources to manage the load of preparation required before each lesson. All the work in a special need class should be prepared beforehand otherwise; the teacher would lose the control of the class from the beginning. TA3 emphasised the need of time for preparation 'no *there aren't enough hours in the day so, time, because there is always lots of preparation to do and lot of things to get ready and resources, there will never be enough resources, no matter how much you got*'.

Concurrently, TA6 consider the time as an important factor for preparing resources *'it is the time really'*.

Resource availability is the second theme which is considered as one of the main point to build the SENTP. SEN students required special resources for all the expensive and difficult to prepare subjects. Hence, resource availability 24-7 can support the teaching staff and student at any time as described by TA1 'I*n my class in particular, we have a lot of ASD students, so it's making sure that we have all of the work set beforehand, [...] We just have to make sure that we have everything ready, first thing for the ASD students, and prepare for them what has to be next because you want to include everybody into the lesson if we can, so just preparation*'. Also, TA6 reported the importance of having up-to-date resources without the need to prepare all the required resources every time '*be able to use whatever most current, newest information, newest resources that are available, we got to use whatever we can to be able to keep developing the children and holding their interest'*.

Research participants pointed out to the **staff training** as an important issue to teach SEN students. Each school has a special system of student communication to follow and different students use different symbol systems. The teaching staff who move school may require using different systems. This was highlighted by all the interviewee as reported by TA3: *'Yes, definitely because (student) does Makaton, I picked up a bit of it but I never done it, I wish I had'.* TA7 consider the need for training for all the staff at the pre-school *'I think all the teachers needs to go to the training'*.

5.8 Evaluation of SENTP

The new SENTP designed is evaluated according to the evaluation criteria and the results from the thematic analysis. The SENTP can accomplish all the criteria as illustrated in Table 5.7 below.

Requirements	Evidence from the interview: quotes and concerns	Aims	Evidence from the interview: quotes and findings	Results
Understanding	T1-pre-interview: 'They would understand things that are concrete not abstract. Abstract understanding in poems is very difficult for special educational needs in general especially autistic kids. That's the danger when you teach poems, you've got to explain what they mean.'	**Better understanding**	T1-pre-interview: 'Well yes I think so because like I said they remembered it, didn't they? I mean we've done certain poems in the past and a lot of them they don't remember but today they did. They remembered exactly what we did, they remembered the name, they remembered you coming in, what you did, so yhaa, I think so.'	**Better understanding/ underlying meanings**
Understand underlying meaning	T1-pre-interview: 'To understand the underlying meaning in the poem, so with some of our ASD pupils they would understand what they read as literal.' 'They understand it at face value as it is literal not the underlying meaning of what the author is trying to get out, that is quite difficult for them to understand.'	**Support with underlying meaning**	T1-post interview: 'Yes, definitely, very, very, very useful. I think again it simplifies what I am trying to teach, and what I am trying to put across to the children so I think, yes.' 'Yes, which you saw from the kids. How they answered the questions, how they found the poem very easy.' 'save a lot of time and more understanding and achievement.'	
Time	T1-pre-interview: 'Yes it does probably take time. It does time.' T1-post interview: 'Yes it does take a lot of time as well. We have to make those cards, which is again as I said, it is time consuming, we can use that time to something more valuable.' TA3: 'No there aren't enough hours in the day sometimes, because there is always lots of preparation to do and lot of things to get ready and resources, they will never be enough resources no matter how much you've got….'	**Save SEN teaching staff time**	T1-post interview: 'Yes it does definitely reduce the time, absolutely.' 'Definitely, because it's what we prepare anyway, we prepare visuals to support, so you now help us to reduce that time by it being done through electronic system or software, absolutely. There is no doubt.'	**Better time management**

Support	T1-pre-interview: 'With poems yes you need more support because of the way they are constructed, the way the poems are written, you can get hundreds of different types of poems and styles, so it would be a bit more complex, possibly more than other areas in English.'	**Better support for the poem**	T1-post interview: 'Yes, which you saw from the kids. How they answered the questions, how they found the poem very easy.' TA3: 'yhaa, it worked ok, didn't it, it is just I think our group is a very difficult group, but from what I can remember, yhaa it did help it.'	**Very good support with teaching poems**
Resources	TA3: 'No there aren't enough hours in the day sometimes, because there is always lots of preparation to do and lot of things to get ready and resources, there will never be enough resources, no matter how much you've got….' 'Well you haven't got the right resources to hand. No matter how organised you are, there was always something.'	**Support/replace resources**	TA1: 'I think, yes, because with cards a lot of time, they're busy fussing with the cards, or they're looking at the cards, so sometimes they miss what the teacher is doing or saying because they are busy fussing with them. So, I think having both of them together on the interactive whiteboard will definitely reduce the cards, and it might replace the cards'	**Can support current resources or could replace them**
Preparation	TA3: 'No there aren't enough hours in the day sometimes, because there is always lots of preparation to do and lot of things to get ready and resources, there will never be enough resources, no matter how much you've got….'	**Support the staff with preparation of everyday work**	TA4: 'I will not ask you this. Do you think it would reduce the preparation required for each lesson, especially for SEN who are visual learners? ohh, yes, definitely.' T1-post interview: '…but if we have this as a tool that we can use it anytime.'	**Help with resource preparation**

Accommodate different abilities	TA1: 'Accommodating the huge needs, the varying huge needs that I have in my class, […]so accommodating for everybody's needs individually, they all have very, very different needs.' R: What is your current concern when you plan a lesson in general in english? T1: Accommodating the huge needs, the varying huge needs that I have in my class, […] so accommodating for everybody's needs individually, they all very very different needs. R: Different needs? T1: Very different, the needs are quite dramatic.	**Can be useful for different abilities**	T1 post interview: 'Yes, definitely, very, very, very useful. I think again it simplifies what I am trying to teach, and what I am trying to put across to the children so I think, yes.' 'yes, I mean I come across people with complex syndrome, people…with general global delay […], and definitely, visual learners, you know, you remember you've got static learners, auditory and you've got the visual learners. I think a lot of our pupils, or a lot of pupils with different needs and different syndromes and different of medical things rely on pictures, rely on visual […] when we demonstrated a similar session with speech and language and a lot of pupils, even adults, rely on symbols outside, so when you see the MacDonald's signs or when you see road signs, people have learned visual symbols rather than word.' […] 'different types of needs.'	**Can accommodate different abilities**
Behavioural problems	R: What is the most urgent case in which you need support during your teaching lesson? T1: To support behaviour […] and understanding for the ones that have low understanding or communication problems.	**Can help with behavioural problems**	T1 post interview: 'Maybe it might be to engage children who have not got so much interest, maybe it can be way of you know engaging them.' T2: 'They were pretty well behaved during the session [...] hopefully'. TA6: 'Yhaa, I think it is nice to have different ways of telling stories. Just different way of engaging their attention.' TA2: 'The interesting thing is that it held their attention for long periods of time.'	**Reduce behaviour problems**

Communication and language	TA3: 'Communication is a problem.' TA9: 'The second thing is communication and language.'	**Can help with enhancing language and communication**	T1 post interview: 'I think a lot, because then for example with all the autistic pupils in my class, they can grouped and then obviously, watch it together – they don't need one-to-one support and my teaching assistants would be freed up to help somebody else who could, you know, use the one-to-one support, not because they need visual support, perhaps because they have other needs that require a teaching assistant, so absolutely, I think it is better than having cards and its better than a teaching assistant sitting and trying to , you know, fussing with cards, yhaa, it would free them.'	**Can help with communication and support language**
SEN mood	T1-pre-interview: 'Yes, the children's moods and how they have come to the class.' 'For all the kids not just for the autistic. If the structure is gone for a day or they get new visitors in, new people out, or the timetable is not followed.' TA3: 'What sort of temper the children were in, because the weather can change it, if it is windy, they can be really difficult, if they are tired, end of the term, they're difficult, so you just need to engage them to how you work with them.'	**Offer better mood for SEN learning**	T1 post interview: 'I think a lot of the students were looking at the symbols and some pictures that you had put up as I was trying to explain the poem.' TA6: 'I don't know, the interesting thing is that it held their attention for a long period of time.'	**Can help to offer a better mood for SEN students**
SEN reading	TA2: 'The main concern is that a lot of the children can't read, and I find it really difficult, well they find it really difficult because they don't know what is expected of them, so that umm and numeracy.'	**Support with reading**	T1 post interview: 'Yes, definitely, very, very, very useful. I think again it simplifies what I am trying to teach, and what I am trying to put across to the children so I think, yes.' TA4: 'Maybe with extending language with the support of the other, with extending vocabulary and stuff and make them familiar with nursery rhyme in [....] to support of other things.'	**Can help with SEN reading**

SEN Numeracy	TA2: ‘The main concern is that a lot of the children can’t read, and I find it really difficult, well they find it really difficult because they don’t know what is expected of them, so that umm and numeracy.’	**Support with numeracy**	TA2: ‘I certainly can think of science definitely, humanities, I would imagine […] maths I am sure it could also be used, I have to think about it, because it is the first time I’ve seen it, so I have to go home and think, if I had to do topic in maths could I use it, I am sure it would be.’	**Can help with SEN numeracy**
Writing	TA3: ‘Some of them have trouble with writing.’	**Can support writing**	T1 post interview: ‘Saving time, facilitating the pupils’ learning, their understanding, then help us to extend them within that area, so we could actually move on and do other things with those visuals, perhaps get them to write using those pictures, maybe they can help in writing.’	**Can help student who cannot write**
Organisation	TA1: ‘You normally know the things that are triggers and you try sort of to be prepared, be organised beforehand.’	**Better organization**	TA3 ‘I mean you can use it for poetry but you can use it for everything can't you? Poetry is an idea of showing it, it can be used for anything’	**Help with class organization**
Lack of staffing	T1-pre-interview: ‘Definitely [...] Definitely at least four pupils in my class that ideally work very well on a one-to-one basis.’ TA3: ‘we could do it with more.’	**Better class management with the number available**	TA1‘Yes. Yes […] sometimes yes. Sometimes.’	**Help if there is lack of staffing**
Training	T1-pre-interview: ‘More training in different areas.’ […] ‘I think because we have a growing autism population in this school, I think more on having autistic friendly classroom, will be definitely be one for me.’ TA9: ‘I think we all need training for SEN, all the teachers.’	**Support untrained staff**	T1-pre-interview: ‘Yes. Definitely.’	**Help untrained staff**

ASD	TA1: 'Well in my class in particular, we have a lot of ASD students, so it's making sure that we have all of the work set beforehand, so if we have to do a class lesson and the whole group has to listen? We just have to make sure that we have everything ready, first thing for the ASD students, and prepare them what has to be next because you want to include everybody into the lesson if we can, so just preparation.'	**Can support ASD students**	T1 post interview: 'Definitely, yes, definitely. I think a lot of the students were looking at the symbols and some pictures that you had put up as I was trying to explain the poem. [..] not all my students needed, or used the symbols, but certainly the autistic pupils in my class found it very useful.' […] 'I think a lot… with all the autistic pupils in my class, they can grouped and then obviously, watch it together they don't need one-to-one support and my teaching assistants would be freed up to help somebody else [..], use the one-to-one support, not because they need visual support, perhaps because they have other needs that require a teaching assistant, so absolutely, I think it is better than having cards and its better than a teaching assistant sitting and trying to[..], fussing with cards, yhaa, it would free them.'	**Can support ASD students**
Concentration in class	T1 post interview: 'Absolutely, because someone like [student-name] who doesn't maintain eye contact with the interactive whiteboard, we have lots of students who struggle to look at the board for a long period of time.'	**Better concentration**	T1 post interview: 'Absolutely, because someone like [student-name] who doesn't maintain eye contact with the interactive whiteboard, we have lots of students who struggle to look at the board for a long period of time, this application absolutely catches their attention. I think it does work because when they look up if they can't access the word they can access the pictures. Definitely.' TA1 'we've done certain poems in the past and a lot of them they don't remember but today they did. They remembered exactly what we did, they remembered the name, they remembered you coming in, what you did.'	**Increase the concentration in class**

Table 5.7: SENTP Evaluation (Iteration 2)

From the above discussion, the SENTP can accomplish all the criteria set in Section 5.3, as illustrated in Table 5.8 below:

Criteria	SENTP
Simple to use	√
Support the staff with the class management skills	√
Support/replace the manual methods	√
4. Saving preparation time	√
5. Support/replace the symbol cards	√
6. Support different types of SEN students' needs and abilities	√
7. Understanding	√
8. Utilised for other class subjects (flexible)	√
9. Increase the motivation and engagement	√
10. Easy to use, edit and maintain	√
11. Offer different types of annotations (Image, Information, Bigger Text, Sound and Symbols)	√
12. Saved on local server	√

Table 5.8: SENTP Evaluation Findings

Although, all the participants believed that SENTP is a useful resource for enhancing SEN education. There are some recommendations mentioned by the participants to improve the design of the SENTP such as bright colours, bigger font, short poems, extended vocabularies and extra images. The recommendation suggested by the participants depend on the student special need issue and their age. All the participants from the pre-school concentrated on the layout of the user interface to increase the students' engagement to achieve better learning. Concurrently, the special school teaching staff suggested developing the user interface to increase their student motivation and reduce behaviour problems which was one of the main concerns in this group. Also, some participants suggested putting the SENTP in practice and employing it in their lessons for a period of time to specify the benefits of using in their classes. This concept, then led the study of utilising the SENTP within wider data to test the efficiency and usability in this special domain. All the interviewee from the pre-school prefered shorter poems, less text language and apply more visual because of their age group. Changing the font according to students' issues as emphasized by TA3 *'It is easy to make things big for children with bad eye sight'*.

5.9 Conclusion and Future Works

This chapter examines the impact of a Semantic Web Annotation tool (Amaya) on enhancing the educational performance – designing educational content. Consequently, the motivations for promoting Semantic Web annotation tools in the education of special needs encourages the design of a new system, which could support special needs education. The new system, the SENTP, created of the core Web language (HTML) and Semantic Web Annotation Tool (Amaya).

It has been seen that the semantic annotation tool (Amaya) benefits the education of special needs in different aspects. SENTP can replace/reduce the use of the existing teaching methods as confirmed by nine interviewees. Also, it can reduce SEN students' behavioural problems and increase their understanding. SENTP presents the teaching material with additional new discription of the language such as the symbol systems (Makaton, PECS and Widgit). The platform increases SEN students' engagement, concentration and motivation. Moreover, it can also support teaching staff with class management and resource preparation. SENTP can be adapted to different subjects and topic as confirmed by all the participants. Additionally, children with English as a second language are also possible end users of the proposed approach. All the participants believed that SENTP can support the autistic children in specific and other SEN issues in general.

There are many participants stressed the point of using the SENTP within wider data and to develop the user interface to be adapted for different issues and ages. This point will be considered for further research. Moreover, there is a need to investigate further to develop the framework for better SEN education results by improving the layout of the SENTP user interface for better understanding. Also, extend the SENTP to be tested acoss other SEN domains. This requires applying a more rigorous evaluation measure to prove the generality and effectiveness of SENTP.

Chapter 6: Field Testing Annotation

Iteration III

‘People often ask, ‘How can you say you're blessed to have a son with Down syndrome?’ My outlook on life has forever changed. I see my own challenges differently. He's always showing me that life is so much bigger than self.’

Yvonne Pierre

6.1 Introduction

This chapter presents an augmented World Wide Web (www) vision utilising annotation to more effectively support diverse special educational needs (SEN) students. It investigates how adaptive special needs educational systems can benefit from the Semantic Web annotation techniques to reduce the SEN cognitive load, then improve student understanding. Improving learner understanding using a variety of teaching materials is important to enhancing the SEN students’ learning because it increases their engagement and concentration. Sweller (1994) showed that understanding is especially difficult when a material with a high cognitive load must be learned. In addition, he added that inappropriate instructional designs can impose a high extraneous cognitive load that interferes with the learning process. An extraneous cognitive load is one that is imposed purely because of the design and organization of the learning materials rather than the intrinsic nature of the task (Sweller and Chandler, 1994). The SEN Teaching Platform (SENTP) design is refined based on the feedback from Iteration 2 (Pilot Study) and a set of requirements developed from previous work for this study. This design is evaluated by conducting field testing annotation in schools caring for SEN students of different types of special needs issues, ages and sectors. This allows the use of SENTP in different educational circumstances. The designed artefacts from iteration 1, 2 and 3 are synthesised within a wider design blueprint that articulate how annotated digital media is designed, deployed and consumed. Moreover, the SENTP ontology from chapter 4 is developed in this chapter to generalise the concept of employing semantic annotation for diverse special needs students and a wide range of learning materials and share the annotated learning content between the stakeholders. Iteration three contributes a detailed practical evaluation addressing the use of semantic annotation in teaching SEN students, a SENTP blueprint and a SENTP ontology model. This chapter is structured as follows:

Section 6.2 demonstrates how Design Science Research is applied to execute this iteration and the outputs of this iteration. Section 6.3 presents the building and development of the SEN Development Media (SDM) framework to build an extended SENTP. Section 6.4 illustrates the evaluation of the research outputs using field testing annotation, with details of the experimental setting. The learning outcome of this iteration is presented in Section 6.5. Section 6.6 describes the results of the study in a SENTP blueprint. Section 6.7 presents the developed SENTP ontology model. Finally, the chapter is summarised in Section 6.8.

6.2 Design Research and Output Artefacts

The learning outcome of Chapter 5 has directed the SENTP improvement in this iteration. The efficiency of the edited SENTP is then tested in domains additional to those in used for testing the previous iteration. In addition, the theoretical ground for the research to illustrate how and why the approach proposed in the SENTP can provide an efficient solution to the problems of special needs learning. The focus of this Design Research iteration is to refine and extend the developed SDM framework to improve the student understanding of the teaching material and increase their motivation in learning. An extended framework involves utilising Cognitive Load Theory (CLT) to improve the layout of the SENTP user interface. As noted in chapter 5, from the pilot study, semantic annotation could have a positive impact on the learning progress of SEN students through improving the level of understanding, increasing motivation and support with resource preparation. Furthermore, Amaya was shown from the pilot study to be a suitable annotation tool for use with SENTP.

This chapter proposes a method for annotating the student teaching material by building the web content using CLT and the output is an annotated poetry webpage (instantiation). In order to progress this research, it is vital to validate the generality of the SENTP tool by understanding how and why it is applicable across other domains. This iteration aims at developing and applying a more rigorous evaluation framework that satisfies the developed user requirements. Evaluating the SENTP approach is achieved by field tesing of the annotation in various domains. Over the past two decades, several studies have established the impact of computer technology on special educational needs (Sajadi and Khan, 2011). However, not much work has been done to cover all the SEN issues. Although, the use of semantic annotation in teaching is considered as a new and limited research area (Devedzic, 2016), the use of semantic annotation in teaching SEN students had yet to be researched prior to this study. Hence, the evaluation poses a challenging task as knowledge as well defined practical evaluation methods have not been established.

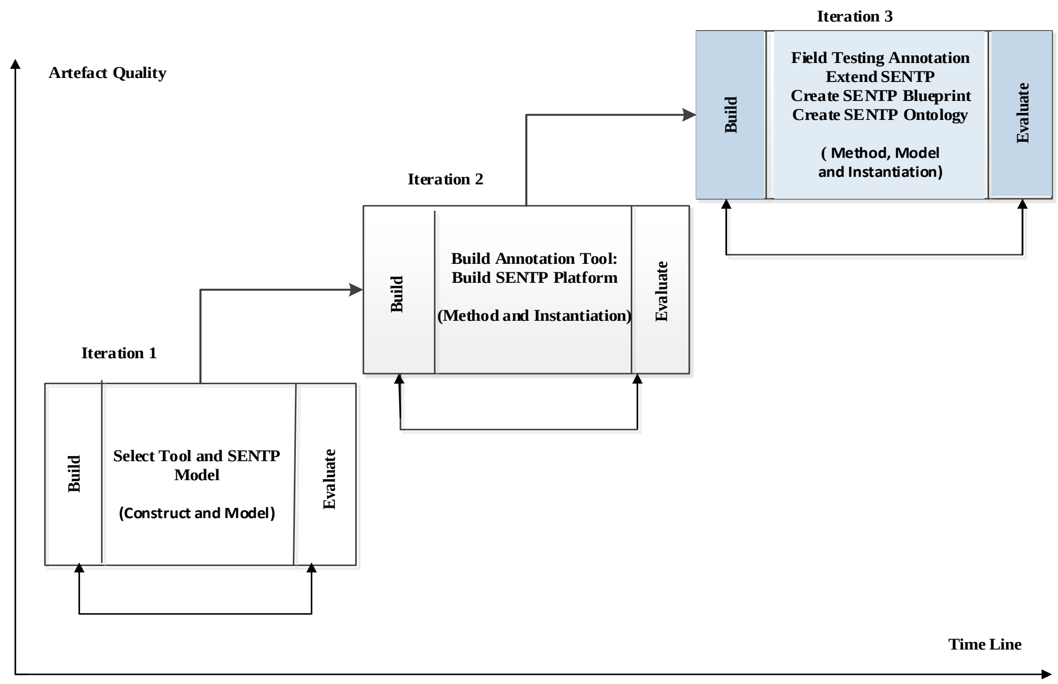


Figure 6.1: Overall Design Research Iterations Framework

6.2.1 Research Design and the Platform Process

This study aims to build and refine a number of micro-designs (content, annotation and process) before designing a blueprint for deployment. Importantly, core theories of learning and memory systems, including those related to cognitive load, direct the design of the SENTP (Marshall and Rossman, 1989; Mayer, 2002). Artefacts (such as web content and the SENTP architecture) are refined to minimise the cognitive load and enable efficient use of working memory in order to improve communication, aid understanding, and reduce the effort and time needed for resource preparation. Feinberg and Murphy (2000) argued that CLT offers a reliable baseline for the design of efficient web-based instruction, impacting the presentation and storing of information in long-term memory. Furthermore, the implications of utilising annotations in reducing SEN cognitive load were evaluated using Amaya. As discussed in chapter 5, pupils in SEN classes have a variety of learning needs and styles (Dawod and Bell, 2011), and the designs should be adapted to the full range of SEN needs related particularly to autism, ADHD, and communication difficulties, which are some of the main issues in SEN schools.

Typically, optimal performance can be achieved by offering presentation strategies that reduce cognitive load (Kalyuga, Chandler, and Sweller, 2000). Consequently, the annotation techniques used with the Amaya tool offer a number of types of annotation for field testing such as images, information, symbol systems (PECS, Widgit, and Makaton), pictures, information, and sound. The artefacts deployed in the classroom (including methods) are generalised into a design blueprint. Finally, a SENTP ontology model will be developed from chapter 4 by utilising the SENTP blueprint method to present OWL ontology model for SENTP. The final refined framework can be summarized in six main steps, as illustrated in Table 6.1. The table presents the Iteration Steps, Method and Input–Output Model.

Steps	Method	Input artefact	Output artefact
1.Identify problems /user requirements identification **An awareness of the problem**	Review the pilot study results	Pilot study results **(Instantiation)**	A proposal for extending the SENTP Redesign the SENTP UI **(construct)**
2.Employ CLT to the design of the SENTP **Suggestion**	literature review (CLT-Redunducy effect, Split Attention effect and Modality effects)	A proposal for extending the SENTP Redesign the SENTP UI **(construct)**	An improved educational poetry website with CLT **(model)**
3. Refine and extend the SENTP model by incorporating CLT principles **Development**	Extend SENTP Annotation process	An improved educational poetry website with CLT **(model)**	Annotated web page text and extended prototype application **(method)** **(instantiation)**

Steps	Method	Input artefact	Output artefact
4.Observe the SENTP in action, with proof of concept **Evaluate SENTP**	Semi structured interviews **(Qualitative method)**	Annotated web page text and extended prototype application **(method) (instantiation)**	A SENTP **(Instaniation)**
5. Create and Design **SENTP blueprint**	Review the Literature, Pilot study and field testing results	A SENTP **(Instaniation)**	SENTP Blueprint **(method)**
6. Develop SENTP **Ontology model**	Design, Build and implement SENTP ontology	SENTP Blueprint **(method)**	SENTP Ontology with OWL and Protégé 5 **(model) (Instantiation)**

Table 6.1: Iteration Steps, Method and Input–Output Model

6.3 Design and Build

This section describes the design of a SENTP framework and subsequent development of content. The design itself is in response to the user requirements described in the following section. Importantly though, each artefact design also considers initial requirements and CLT theory.

6.3.1 Research Requirements

The requirements are based on the literature review and an earlier pilot study in chapter 5 which shows some limitations that require attention. In addition, the designed artefacts in this chapter need to be synthesised for a wider design in a blueprint. The blueprint demonstrates how this SEN world of annotated digital media is utilised. To achieve the goals of this research and to overcome the limitations from the previous iteration described in chapter 5 (Pilot Study), a set of user requirements is identified in Table 6.2.

No	Description	Literature	Findings from pilot study	Interview No
1	The user interface (UI) should limit SEN students' communication and language difficulties, including English as a second language.	'Having language delay with autistic children can cause problems with reading, writing and spelling. There are other problems such as memory and organizational skills' (Perko and McLaughlin, 2002; Glazzard et al., 2010).	Chapter 5, Section 5.5.2 Number 1, and Evaluating Findings, Section 5.6, Table 5.7, T1, T2, TA2, TA3, TA7	Interview 1, 2, 4, 5, 6, 9
2	The UI should be improved to increase students' engagement and reduce behaviour problems during the teaching process. In this way, SENTP can also support students with ADHD issues.	'They are too often disruptive in the regular classroom; thus, you are depriving the regular students of the complete education they deserve. Thirdly, it can lower the esteem of the special needs child because they soon realize they are incapable of doing the same work as their peers, and begin to act out.' (Dawo, 2015) 'An autistic child has difficulty with social interaction, communication skills, imagination and they can be easily distracted.' (Glazzard et al. 2010) For students with disabilities, engagement (participation of the child in learning) is the single best predictor of successful learning (Bulgren and Carta, 1993; Iovannone et al, 2003; Carpenter, 2010).	Chapter 5, Section 5.5.2 Number 1, and Evaluating Findings, Section 5.6, Table 5.7, T1, T2, TA1, TA3, TA5, TA6 Interviews	Interview 1, 2, 3, 5, 6, 8
3	The UI should improve SEN understanding, including the underlying meaning of words.	'They are incapable of doing the same work as their peers, and begin to act out.' (Dawo, 2015)	Chapter 5, Section 5.5.2, Number 2, and Evaluating Findings,	Interview 1, 3

No	Description	Literature	Findings from pilot study	Interview No
			Section 5.6, T1, TA1	
4	The system should save preparation time, support staff with classroom management, help untrained staff (e.g. more resource availability)	'The reports mark a radical response to concerns that workload is one of the major challenges affecting teachers.' (Department for education Morgan MP, 2016) (Gharbieh, 2009)	Chapter 5, Section 5.5.2 Number 3, and Evaluating Findings Section 5.6, T1, TA1, TA3, TA7	Interview 1, 3, 4, 9
5	The UI presentation should have clear information, real images, large font sizes and bright colours.	'Visual learning techniques are used widely in schools across the country to accomplish curriculum goals and improve student performance.' (Aurthor, 2011)	Chapter 5, T1, T2, TA2, TA4, T5, TA7 Interview	Interview 1, 2, 4, 6, 7,9
6	The system should be easy to use, edit and maintain to avoid any technical issues.	SEN students have low tolerance level and a high frustration level (Fredericks, 2005).	Evaluation Criteria Section 5.3.1, TA3	Interview 5
7	The SENTP should have the potential to benefit different subjects.	'Visual learning techniques are used widely in schools across the country to accomplish curriculum goals and improve student performance.' (Aurthor, 2011)	Chapter 5, 5.5, Evaluation, Table 5.5, T1, TA1, TA2, TA7 TA6	Interview 1, 3, 4, 8, 9
8	The annotations should be presented as a one learning source such as image and text or symbol cards and text.	'They find integration of information is difficult. It can be difficult and physically overloaded.' (Loprestl, Bodine and Lewis, 2008)	T1, TA2, TA5 Interview	Interview 1, 4, 7

No	Description	Literature	Findings from pilot study	Interview No
		A study conducted by Plass et al. (1988) with 103 participants showed that learners recall better with individual vocabulary items accompanied with visual and verbal annotations of these words rather than when they use one or the other.		
9	Each page should be introduced as one source, rather than many replicated sources. Hence, one source can include image, text and information (addressing the redundancy effect and the coherence effect).	'The use of images, along with words, diminishes the overwhelming nature of text and helps the student to manage the cognitive load, which increases retention.' (Van Merriënboer and Sweller, 2005)	T1, TA2, TA5 Interview	1, 4, 7
10	Each page should be presented as a source with combined learning material such as visual (image, symbols) with sound (the modality effect).	'Replace a written explanatory text and another source of visual information such as a diagram (unimodal) with a spoken explanatory text and a visual source of information (multimodal).' (Van Merriënboer and Sweller, 2005)	TA4, TA5	6, 7
11	The system should support or replace manual teaching methods, such as symbol cards.	'Without greater use of visual learning in schools and other places of learning, many 'Students are under-performing because of the inconsistency between teachers, teaching styles and students' learning styles.' (Zane, 2015)	Chapter 5, Evaluation Criteria Section 5.3.1, T1, T2, TA1, TA4	1, 2, 3, 6
12	There should be the option of displaying visual materials (images, symbol systems) while staff verbally demonstrate the system, or the learners use headphones along with the visuals.	'Words process in the verbal channel and pictures process in the visual channel. Thus, both verbal and pictorial information require to be integrated.' (Paivio, 1991; Sajadi and Khan, 2011)	Chapter 5, TA4	6

No	Description	Literature	Findings from pilot study	Interview No
13	It should be possible to explain at the beginning of the lesson how the system works and to provide pre-training (the goal-free effect).	'Evidence from (Moreno, 2004; Tuovinen and Sweller, 1991cited in Kirschner et al, 2006) illustrates that students become lost and confused with the pure discovery learning system.' (Sajadi and Khan, 2011)	Chapter 5, T1, SENTP evaluation	1
14	The system should be able to support students with differing severities of autism.	'People with autism they demonstrate excellent performance on visually presented tasks and other tasks that support direction […]. However, they find integration of information is difficult. It can be difficult and physically overloaded.' (Loprestl, Bodine and Lewis, 2008) 'Autistic, ultimate learning disability because of the difficulty in languages and social behaviour. He declared that educating students with autism is a challenge for special educational needs teachers.' (Perko and McLaughlin, 2002)	Chapter 5, SENTP Evaluation 5.6, Table 5.5, Interviews: T1, T2, TA1, TA3, TA6, TA7	1, 2, 3, 5, 8, 9
15	The SENTP should improve understanding, increase engagement and motivation.	'Teachers showed awareness of the need for low-attaining pupils to be able to focus on the task in hand.' (Dunne et al., 2007)	Chapter 5, T1, T2, TA1, TA3, TA6, TA7	1, 2, 3, 5, 8, 9
16	To design SENTP blueprint method that articulates how annotated digital media is designed for SEN students.	It allows an integration of the different components of the study, enabling links and interactions to be displayed clearly within the layers of information (Kalbach, 2016).	Chapter 5, T1, TA2	1, 2
17	To design ontology which presents a proposed model for annotating SEN content for different SEN issues, age range and learning styles.	Previous work by Dawod and Bell (2011) covered in Chapter 4.	Chapter 5, T1, TA2	1, 2

Table 6.2: SENTP User Requirements

6.4 The SENTP Framework

The most important concept of CLT that is of relevance to the practice of designing SENTP is that, to a certain extent, teachers and learners can favourably control the learning process if three conditions are observed. Firstly, extraneous cognitive load should be kept to a minimum. Secondly, the sum of intrinsic and extraneous cognitive load should not exhaust working memory capacity. Thirdly, SENTP should be designed such that it stimulates learners to allocate their available working memory resources to dealing with intrinsic cognitive load to given tasks.

The objective of using ideas surrounding CL in the SENTP is to examine a key question. ‘How can semantic annotation techniques reduce the SEN student’s cognitive load to achieve better learning’

There are two aspects to CL as explained by Sweller (1994):

- Reducing intrinsic load: The design of the SENTP should consider the ability of semantic annotation to lower the cognitive load by reducing task complexity, as explained by Ayres (2006). This will be done by adding different forms of annotation, real images, and improving the presentation layout of the UI by using different colours and fonts relevant to the needs of the SEN user.
- Reducing any extraneous CL imposed by the instructional design itself through the integration of the annotations.

  A further CLT theme is that working memory (WM) is vital for performing any mental task, but is limited (Mayer et al., 2001, Clark et al., 2012;). One of the main aims of CLT is to ensure that learners’ WM is not be overloaded by the information presented (Pass et al., 2010). Some cognitive tasks are more challenging, and a larger working space is required to complete any cognitive task involving material that is difficult to understand, according to Epps and Ambikairajah (2011). Pickering and Gathercole (2004) write that children with general learning difficulties perform poorly on tasks that required large WM, and so extra effort is needed to use WM efficiently to improve their learning. Baddeley (1992) stated that information can only be stored in long-term memory after first being dealt with by WM. A focus of the design is to reduce the unnecessary cognitive burden on WM to support efficient learning and to highlight basic methodologies for reducing the effects of the extraneous cognitive load to ensure optimal learning (Merriënboer and Sweller, 2005). Figure 6.2 presents the SENTP framework.

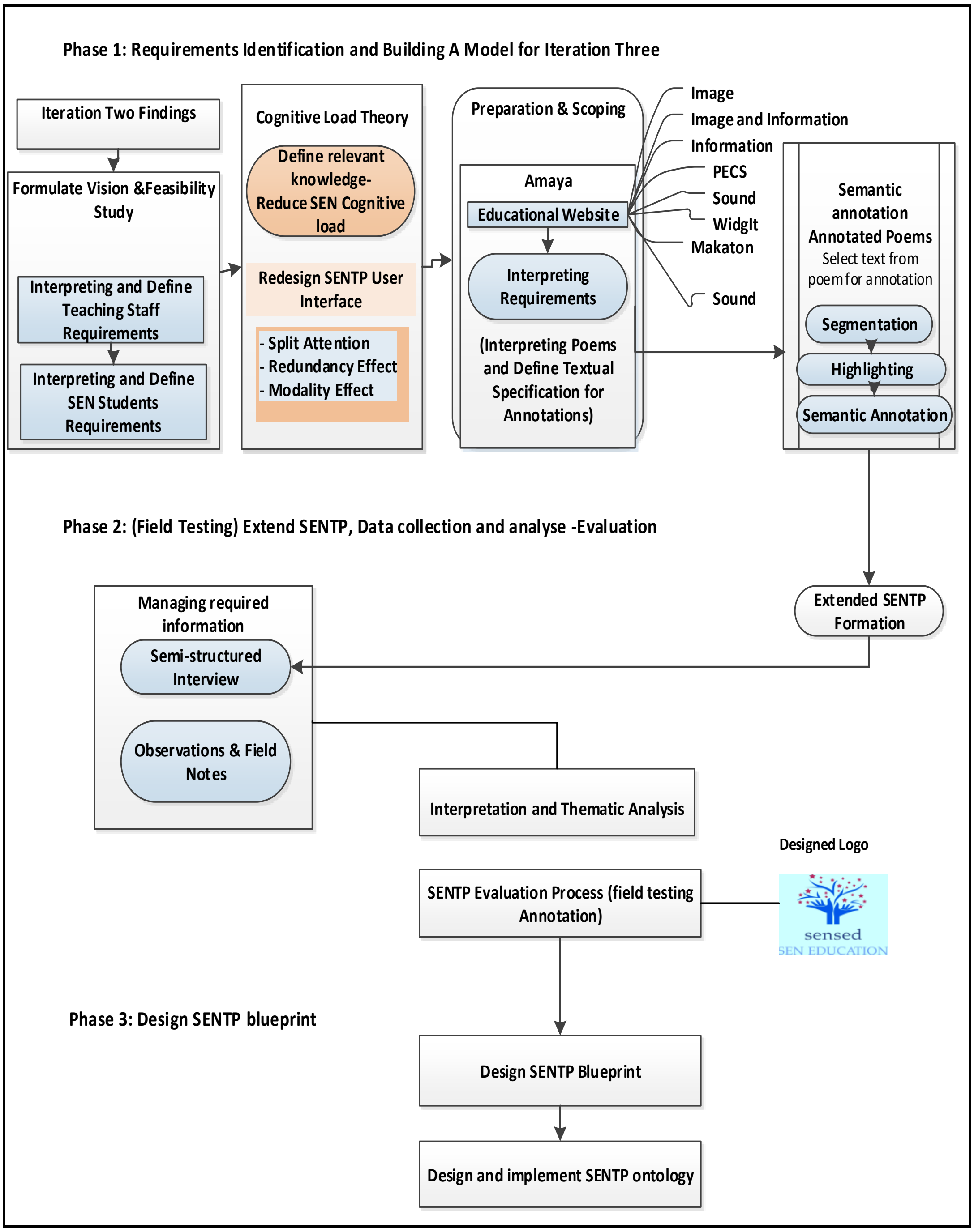


Figure 6.2: Extended SEN Teaching Platform (SENTP) Framework

Amaya is certainly a good starting based on the finding from the pilot study which pointed for creating an annotation tool that supports teaching and learning of SEN students; however, it needs to be modified to meet the SENTP requirements listed in Table 6.2. The features that need to be modified are as follows:

1. The SENTP should have an option of displaying visuals (images, symbol systems such as Makaton, PECS and Widgit) while verbally demonstrating the platform, or the provision of audio annotation using headphones with the visuals to reduce a contiguity effect (Tabbers et al., 2004).

2. A combination of text and visuals such as images or symbol systems or text and sound can reduce the split attention effect. Cognitive capacity in working memory is limited, so if a learning task requires too much capacity, learning will be hampered. For SEN students, the working memory is even smaller Sweller (1994). The recommended solution is to design instructional systems that optimize the use of working memory capacity and avoid cognitive overload. These results in reducing the time required to keep information active in working memory, without the need to integrate information resources mentally.

3. The learning content should include short text to reduce the intrinsic load.

4. Visuals should include enough information to reduce the redundancy effect.

5. Supporting explanation at the beginning of the lesson – the goal free effect, pre-training - encouraging learners to focus on the learning.

Importantly, educational content, described in chapter 4 and 5, enables exploration of the influences of semantic annotation on SEN teaching and learning, including motivation, understanding, communication, and satisfaction. Field testing is used to examine the effectiveness of the SENTP.

The feedback from iteration 2 showed a number of SEN cognitive load issues that needed to be improved such as developing their memory limit. For example, the key features of working memory are the capacity to hold material in mind and manipulate as necessary for brief period, mental workspace, limited in capacity and catastrophic loss (Gathercole and Holmes, 2014).

In addition, the feedback from the teaching staff showed the significance of developing understanding, engagement, behaviour and resource preparation for an effective SEN learning. Hence, SENTP instantiation will be extended to apply CLT principles within the SENTP UI. CLT has an extensive impact on developing understanding, engagement, behaviour and resource preparation in comparisons with other learning theories.

Before selecting CLT, a comparison of different learning theories is conducted. Mat Sin (2011) in table 6.3 compared different learning theories (Behaviourism, Cognitivism, Constructivism and Humanistic).

Comparison among L. Theories	**Behaviourism**	**Cognitivism**	**Constructivism**	**Humanistic**
List of Key Theorists	B.F. Skinner Ivan Pavlov Edward Thorndike John B. Watson	Jean Piaget Robert Gagne Lev Vygotsky	John Dewey Jerome Bruner Merrill Lev Vygotsky Seymour Papert	Abraham Harold Maslow Carl Rogers James F.T Bugental
Role of Learners	Learners are basically passive, just responding to stimuli	Learners process, store and retrieve information for later use - creating associations and creating a knowledge set useful for living.	Learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge, social interactions and motivation which affect the construction.	Learning is an active process/pupils participate actively in Learning activities - Pupils determine the learning materials, method of learning, quantity of learning and values
Role of Teachers	Teacher presents the information and then students demonstrate that they understand the material. Students are assessed primarily through tests.	Instructor manages problem solving and structured search activities, especially with group learning strategies.	Instructors tailor their teaching strategies to student responses and encourage students to analyse, interpret and predict information.	facilitator and organiser to motivate pupils to use their own learning strategy to achieve self-perfection
Key Concepts	Learning is better when the learner is active rather than passive.	Cognitivism focuses on the brain. How humans process and store information is very important in the process of learning.	Constructivism focuses on how learners construct their own meaning. They ask questions, develop answers and interact and interpret the environment.	Humanism focuses on recognising human capabilities in areas such as creativity, personal growth and choice.

Table 6.3: Comparing Learning Theories Mat Sin (2011)

After comparing all the above learning theories, Cognitivism is selected as a theory that can be used to test the level of student’s communication and understanding because special needs children are different and learn differently. Cognitivism is concerned with person’s thinking process. Cognitive theories focusing on how people process information and learn. They discuss concepts such as memory, problem solving and decision making which almost it is the main problem for SEN students (Perko, 2012).

A description of the parts of the theory adapted is explained in detail to understand how and why the theory is utilised to develop the SENTP. CLT focuses on instructional methods to decrease extraneous cognitive load so that available cognitive resources can be fully devoted to learning (Van Merri¨enboer and Sweller, 2005). Based on the feedback from the interviews conducted in the pilot study, all the participants (teachers and teaching assistants) have extensive concerns on improving the students' understanding and communication. They referred to the significance of utilising more than one media for teaching SEN students. This requires mental integrations of all these types of resources for an effective learning. Students designated as SEN acknowledged having lower congnition than other students at the same age, which naturally effects their level of understanding.

There are a number of proposals, underpinned by CLT principles, focusing on pupils learning. Sajadi, Khan and Tariq (2014) argued that when presenting instructional materials for pupils with SEN, it is better to take advantage of both channels, auditory and visual as opposed to a single channel. Brame (2015) argued that managing cognitive load for both channels in multimedia learning materials promise to enhance learning. Sweller's theories (Sweller, 1994; Sweller, 2002) are best applied in the area of the instructional design of cognitively complex or technically challenging material. The theories focus on the reasons why people have difficulty learning specific learning material. CLT has many implications in the design of learning materials for greater effectiveness, minimizing load for learners during the learning process.

The principle known as 'multimedia principle' states that 'people learn more deeply from words and pictures than from words alone' (Mayer, 2009, p. 47). However, simply adding words to pictures is not an effective way to achieve multimedia learning. The goal is to instructional media in the light of how human mind works. This is the basis for Mayer's cognitive theory of multimedia learning. Nevertheless, Mayer's model (Mayer, 2001; Mayer, 2002) was developed without accounting for children with special needs. He suggested testing the model on children with special needs, such as those with autism or Down's syndrome; where there is a greater need to reduce processing in the auditory channel. Moreover, Khan (2010) stated that controlling cognitive load is highly significant when dealing with children with special needs such as autism or Down's syndrome since they tend to have different visual and auditory balance compared to commonly developing children. Complicated or irrelevant information should be reduced when designing multimedia messages for special needs children, even more than for typically developing learners (Khan, 2010). Sajadi and Khan (2014) tested a pedagogy framework design in social networked-based learning and their focus was on children with special needs, specifically ADHD learners. They examined the pedagogical elements of an instructional design for online social learning mediated through Web 2.0 technologies. One objective was to examine the design of learning experiences that could help special educational needs learners to overcome their inherent difficulties and to develop their strengths. Sajadi and Khan (2014) claimed that teaching methods, learning tools and facilities, and content might also be significant in respect of improving learning performance. For instance, many psychological learning theories have been applied to special need, and cognitive load theory by Paivio (1990), and Chandler and Sweller (1991) is one of them. Consequently, special educational teachers should develop an individual teaching plan fit for a child with special needs (Sajadi, and Khan, 2014). Errey et al. (2014) states that high extraneous load occurs when the learner tries to extract information from multiple sources and subsequently integrate then. The same load is required with existing teaching methods such as symbol system cards and images. The majority of studies in the area, are concentrated on this type of load and how it can be reduced (De Jong, 2010). Full description of the CLT principles described as follows:

Split-attention effect: Occurs when learners are required to split their attention between two or more sources of information and then mentally integrate them. Cognitive load theory has been used to generate and explain the split-attention effect (Kalyuga, Chandler, and Sweller, 2000). Dual-processing models of memory suggest that there are separate auditory and visual channels (Baddeley, 1992; Pass, Van Gog and Sweller, 210; Patton, 1980). Splitting and integrating may place a strain on limited working memory and hinder learning (Chandler and Sweller, 1991). Kalyuga, Chandler, and Sweller (2000) described an alternative to dealing with split-attention instructional formats, combining audio and visual presentation. This combination ensures working memory is not overwhelmed.

Redundancy effect: Hinders learning by an excessive amount of information being presented to learners. This can take one of two forms. First, there can be identical information given in two or more forms, such as pictures and words, or text in both written and audio forms. If one of these forms is redundant, its elimination may enhance learning (Mayer, 2001). A second hindrance can occur when additional information is presented in order to enhance or elaborate other information – one example being a full text and a summary of the text. If the elaborations in the full text are redundant, then the elimination of the additional information may again result in enhanced learning. This is also referred to as the coherence effect (Mayer, 2001).

Modality effect: Is closely related to the split-attention effect and often considered to be a possible way of dealing with split-attention. It typically occurs when two sources of information are unintelligible in isolation (Khan, 2010). This effect can result from engaging both auditory and visual channels of information in WM rather than just the visual channel (Khan, 2010). Learning is enhanced when teaching material is presented verbally with visuals, rather than text (Sweller, 1994). For example, rather than presenting a diagram and written text that rely on the visual channel, diagrams and spoken text that rely on both auditory and visual modalities can be used. Figure 6.3 illustrates the CLT principles models which will be adopted in SENTP.

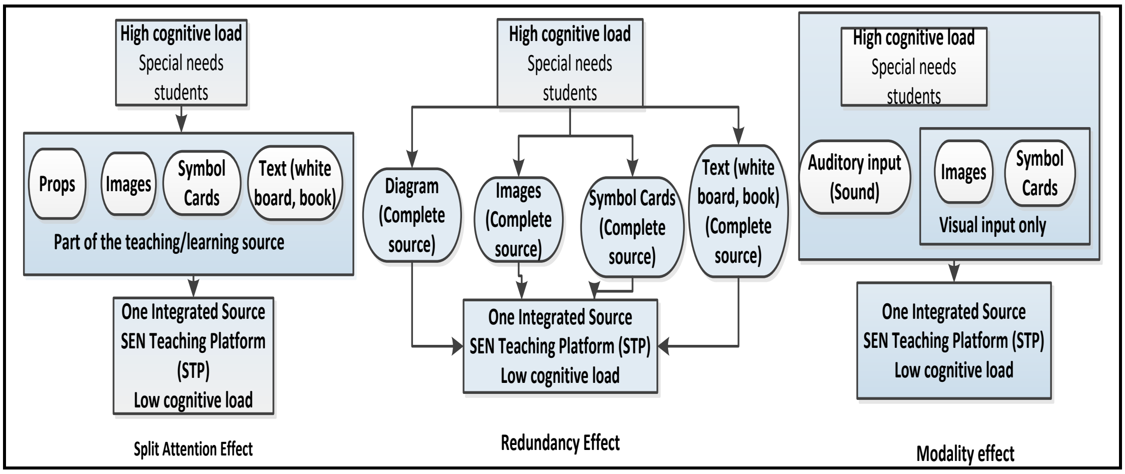


Figure 6.3: Cognitive Load Theory Models Utilised in SENTP User Interface

6.5 Field Testing and Data Collection

Data was collected whilst field testing the designed artefacts. The aim was to gather data in order to assess and further develop the SENTP framework and educational content. Data collected in this study was qualitative, collected from February 2013 to October 2013. Semi-structured interviews were used, in addition to field notes and researcher or staff observation. The interviews provided an opportunity to explore personal experiences that may otherwise have been hard to observe (Patton, 1980, Marshall and Rossman, 1989). The data collection activities are described below.

6.5.1 Participant Recruitment

The field testing annotation interviews were carried out at six schools in the UK: two nursery schools with some SEN students aged 2.5–5 years; two special schools that care for different levels of needs (including severe/profound general learning disability) aged 11–19 years; one state primary school that has students with learning difficulties for children aged 7–11 years; and one pre-school for speech, language and communication difficulties for children aged 2 years and 9 months to 4 years. The selected schools cover different types of SEN levels and needs. The data resulted from two staff categories- teachers and teaching assistants. In total, 22 teaching staff participated in the research, while, 3 headteachers were also involved at the initial stage when contacting schools for approval and scoping and during class observations. Table 6.4 provides an overall description of the participants and Table 6.5 illustrates the composition of the interviewee sample across the six schools.

Description	Total
Sample Size	22
Gender Female Male	 20 2
Age Range SEN Children	(2.5-5), (6-11), (11-19)
Teacher Preschool Teaching Assistant Preschool Manager/ Deputy Manager	7 7 2

Description	Total
Special High School/ Teaching Assistant	4
ICT Technician	1
Head Teacher	1
Special High School for SEN (Secondary)	2
Special Nursery School (Pre-School) for Speech, Language and Communication Difficulties	1
Special Nursery Cares for SEN (Pre-School)	2
State School Cares for SEN (Primary)	1

Table 6.4: The Overall Description of the Participants

6.6 Interview Preparation

6.6.1 Research instruments

The main research tools were the interview questions framework for the teaching staff (See appendix D), and the website supported by Amaya software. The questions were direct and open-ended to allow participants to be more engaged and detail their experiences. An example learning website was designed using HTML, supported by Amaya, containing poetry of different styles as the sample of teaching materials. The NVivo11 software package was employed to carry out thorough and reliable qualitative data analysis. It is a very reliable management tool that can aid in analysing the data (Zamawe, 2015).

6.6.2 Materials

A prototype was presented in schools on a laptop and a projector in a classroom. A digital voice recorder, 'Olympus VN-8600PC', was used along with a small notebook and a pen for extra notes.

6.6.3 Security

All the interviews were managed by the researcher using the interview sheet. All recordings were transferred onto a personal laptop and two USB drives secured with a password only to the researcher.

6.7 Data Sources

Following the ethical approval given by the university, as presented in Appendix B, sixty-one schools caring for SEN students were approached via email, telephone and the postal service. Each school was sent a covering letter along with an information sheet. Six schools agreed to participate in the research. The data was collected over a six-month period due in part to the scheduling and timing pressures within a typical school. In total, twenty-two interviews were conducted. The selected schools each had different teaching environments, students' educational styles, age ranges and backgrounds. All interviews were conducted after a short demonstration of the prototype that followed a briefing session with the headteacher determining the suitability of the SENTP to each school's specific needs. The interviews were typically of 30-minute duration, in consideration of time restrictions. When designing interview questions, it is vital to ask questions that address the aims and objectives of the research. Some questions were intended to gain knowledge about participants' background and experience and to determine their expectations. The data was also collected from school visits, observing the students in class with SEN teaching. Extra time at the end of the interviews was made available for participants to discuss any further ideas or recommendations. Figure 6.4 shows a picture taken by the pre-school manager while the researcher demonstrated the SENTP, accompanied by a member of the teaching staff.

Figure 6.4: A Demonstration at Pre-School (A photograph taken by TA4-M-SN)

The research details were explained to each participant, and an informed consent form provided for the participant to sign and give permission to conduct the interview. Furthermore, an information sheet with full details about the research was given to each participant. All were also told that they were free to withdraw from the study at any point, without having to give a reason why. All arrangements regarding confidentiality of data were explained clearly before the interviews. This process gave participants some idea of what to expect from the interview, gains a level of trust, and is a fundamental aspect of the informed consent process. All interviews were recorded (see Appendix B for all the interview evidence).

The SENTP was demonstrated in the two special secondary schools by the class teacher. However, all demonstrations at the pre-schools were conducted by the researcher accompanied by an experienced member of the teaching staff due to time restrictions and staff shortages. Field testing the content annotation process starts by preparing a consent form, ethical approval and the researcher criminal records bureau (CRB) checks. Headteachers were contacted via telephone, postage system, and email. The headteacher or the staff member responsible for agreeing to participate in the research decided if the demonstrations were to be given as a focus group with teaching staff or to students in class. Teachers from participating classes selected a convenient poem and made editing suggestions if needed.

NO	Code	Job	Sector	Class	Gender	Speciality	Training	Experience	Type of special needs
1	T1-M-SMA	Teacher	Special Needs High School	Severe learning disability	Female	SEN	Dealing with autism in classroom, BED (behaviour emotional disorder)	All SEN, all Subjects, 11–19 years, 16 years' teaching experience	Severe disabilities
2	T2-M-P	Teacher	Pre-School	Nursery	Female	Manager/ Foundation Stage	SENCO, Makaton	EYFS curriculum, three months to five years	Speech delay, hearing impairments and visual impairments
3	TA1-M-SMA	Teaching Assistant	Special Needs High School	Severe learning disability	Male	ICT Technician	No training	SEN ICT support, support all ages in school from 11–19 years	All types (i.e. autism, severe disabilities, blind and partial sight, deaf)
4	TA2-M-SMA	Teaching Assistant	Special Needs High School	Severe learning disability	Female	SEN, Key Worker	Different types of training including Makaton	All SEN, all Subjects, 11–19 years	All types (i.e. ASD (autism), SLD (severe learning disability), blind and partial sight, deaf)
5	TA3-M-P	Teaching Assistant	Pre-School	Nursery	Female	Foundation Stage	No training	Early years foundation stage (EYFS), 3 months to 5 years	Speech delay, autism
6	TA4-M-SN	Teaching Assistant	Pre-School	Nursery	Female	Foundation Stage	No training	EYFS, 3 months to 5 years	Not specific
7	TA5-M-SN	Teaching Assistant	Pre-School	Nursery	Female	Foundation Stage	SENCO, NVQ child care	EYFS, 2–5 years	All SEN children
8	T3-M-SN	Teacher	Pre-School	Nursery	Female	Foundation Stage	SENCO	EYFS, 2–5 years	Speech and language delay, ADHD
9	T4-M-SR	Teacher	Pre-School	Reception	Female	SENCO Coordinator	No training	EYFS, 3–5 years	Not specific
10	TA6-M-SR	Teaching Assistant	Pre-School	Reception	Female	Foundation Stage	No training	All subjects, 2–5 years	No experience with SEN children
11	T5-M-SM	Head Teacher	Pre-School	Pre-School	Female	Foundation Stage	No training	Nursery manager, 2–5 years, teaching adults	All SEN
12	T6-M-SMO	Teacher	Special Needs High School	P3	Female	SEN	Dealing with autism in classroom, BED (behaviour emotional disorder)	All SEN	Severe learning difficulties
13	TA7-M-SMO	Teaching Assistant	Special Needs High School	Severe learning disability	Female	SEN	Different types of SEN training, Signalong, PECS and Widgit symbols	All SEN	Profound, multiple learning disabilities, autism, Down syndrome, Fragile X Syndrome, global developmental delay
14	T7-M-SMO	Teacher	Special Needs High School	Severe learning disability	Male	SEN	Train through experience, SEN school courses	All SEN, all subjects. age 6–19 years	Severe learning difficulties

NO	Code	Job	Sector	Class	Gender	Speciality	Training	Experience	Type of special needs
15	TA8-M-SMO	Teaching Assistant	Special Needs High School	Severe learning disability	Female	SEN	Different types of SEN training, Signalong	All SEN, experience with 5-30 years within school and outside the school	Severe learning difficulties (all types of PMLD and autism apart from Down Syndrome)
16	TA9-M-SP-CH	Teaching Assistant, Key Worker	Pre-School Language Resource	Nursery	Female	Language and communication. Early stage foundation curriculum.	Makaton, speak therapy Signalong	EYFS, 2 years and 9 months to 5 years, language and communication delay, Makaton	Global delay or special language delay
17	T9-M-SP-CH	Teacher/ Manager	Pre-School Language Resource	Nursery	Female	Language and communication. Early stage foundation curriculum.	In house training, SENCO	EYFS, 2 years and 9 months to 5 years, language and communication delay	Language and communication delay
18	TA10-M-SP-CH	Teaching Assistant, Key Worker	Pre-School Language Resource	Nursery	Female	Language and communication. Early stage foundation curriculum.	Makaton, signalong, behaviour management course, in house training	EYFS, 2 years and 9 months to 5 years, language and communication delay	Language and communication delay
19	TA11-M-SP-CH	Deputy Manager	Pre-School Language Resource	Nursery	Female	Language and communication. Early stage foundation curriculum.	Communication courses	EYFS, 2 years and 9 months to 5 years, language and communication delay. Years 1, 2, 3 and 4	Severe speech and language impairment, Asperger’s
20	TA12-M-SP-CH	Key Worker	Pre-School Language Resource	Nursery	Female	Language and communication. Early stage foundation curriculum.	In house training, SENCO	EYFS, 2 years and 9 months to 5 years, language and communication delay	Speech and language delay
21	T8-M-PI	Teacher	Primary Junior School	All class, middle school	Female	Special needs coordinator, reading and comprehension skills	SENCO	Support teaching, reading and comprehension skills, writing groups for gifted and talented group, children with additional language, gifted and talented children, worked in infant schools 7–12 years	Down syndrome, autistic children, dyslexia, speech and language needs, cerebral palsy, hearing and visual impaired
22	T7-M-SMO	Head Teacher	Special Needs High School	Severe learning disability	Male	All SEN	Different types of SEN training and management	ALL SEN, ages 6–19 years	Severe learning difficulties

Table 6.5: Participant Descriptions

6.8 Annotating Educational Content

Semantic annotation (using Amaya) underpins the educational content selected in this study. First, the class teacher selects the type of annotation, the style of the poem, then the poem appropriate for the class demonstration. The platform is prepared beforehand with the kind of annotation required (e.g. images or Makaton symbols). The annotation options are wide-ranging, depending on the SEN age and needs.

Figure 6.5 presents the poetry webpage with different annotation options. Figure 6.6 depicts an annotation with a Makaton symbol ('scare'), and Figure 6.7 presents another annotation with a Makaton symbol ('monster'). This was part of the work demonstrated at the secondary special schools. Figure 6.8 presents an annotation using an image and information. This was part of the work demonstrated at the pre-schools. Figure 6.9 is another example of annotation with image and information, which was demonstrated at the pre-school that cares for children with speech and language delay and another secondary special school that cares for some special needs students. (See Appendix C)

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Figure 6.5: SENTP Homepage

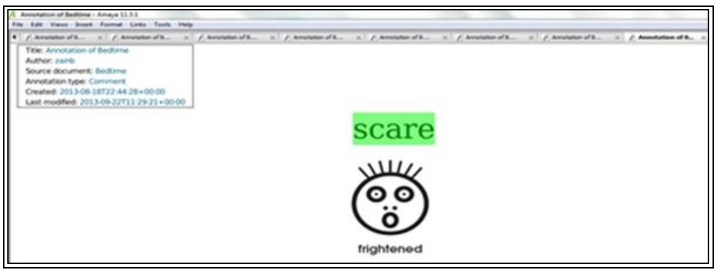

Figure 6.6: Annotating the Word 'scare' with Makaton Symbol

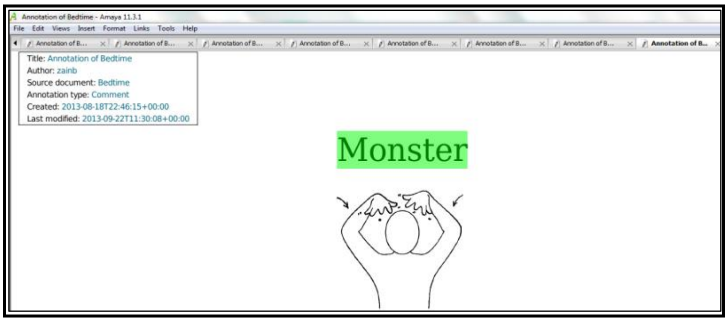

Figure 6.7: Annotating the word 'Monster' with Makaton Symbol

Figure 6.8: Annotating the Word 'Camel' with Image

Figure 6.9: Annotating the text 'The Little Finger on the Right' with Image

6.9 Thematic Analysis

Thematic analysis is used as part of the wider design process to elicit future requirements and more importantly determine artefact effectiveness. Consequently, the SENTP design with the Amaya annotation is assessed during interviews, using

CLT instructional implications to examine reductions in cognitive load (CL). All interview data were analysed using thematic analysis (Braun and Clarke, 2006). After gaining familiarity with the data, the transcription analysis process involved listening to the interviews, reading through the data and uncovering possible themes (Braun and Clarke, 2013). First codes were generated from the transcript information. The qualitative data analysis software NVivo11 was used to facilitate the thematic analysis. The transcript data was exported to NVivo11 that then coded the features from the entire dataset. Themes were identified and reviewed. Each theme captured something important about the data in relation to the requirements and problems being addressed. All data relevant to each theme was extracted to ensure they connected first with individual codes and then with the theme itself. A model of themes is presented to show the connections and relationships between the themes and the subthemes (Braun and Clarke, 2006). Table 6.6 outlines nine codes, themes and sub-themes, along with the number of times each theme and sub-theme was mentioned by participants. (It should be noted that all the transcripts written without changing)

Codes	Theme	Sub-Themes	Quotations from Transcripts
Current Teaching Methods	**Current teaching resources and how the teachers demonstrate** Manual (21), Computer with application (14), Support (2), Preparation (8), Differentiation (12)	Internet, visual (12), Images (10), Symbol systems (5), Application (4), Sound (3), Flashcards (7), Games (4), Smaller white board (1), Musical instrument (1), Online resources (1), Plastic letters (1), Sign language (4), One-to-one support (1), Preparation time (8), Difficult to support (1)	T1-M-SMA: 'Yes, and it is incredibly time consuming for us to do it […]' TA3-M-P: 'Yes we do a lot of picture cards, so they can point lots at what the activity says what the picture is about and if they like the activity, like to teach them to wash hands or lunch time' TA10-M-SP-CH: 'Whatever we are doing is visual. If we have a topic about food, we prepare the symbols and the pictures'
Current Concerns	**Teachers' beliefs about the main concerns in special needs schools** Understanding (4), Behaviour (4), Class management (2), Communication (9), Engaging (8), Individual needs (7), Independency (2), Simplicity (3), Preparation (3), Staffing (1), limited Physical Movement (1)	Understanding underlying meaning (2), Behaviour problems (3), Preparation time (3), Reading and understanding (i.e. understanding vocabulary (1), Inferential understanding (1), Lack of attention (6), Physical movement (e.g. cannot turn the page) (1), Engaging (3), Simplicity (3), Differentiation (4), Emotional language (1), Working independently (1), Managing large group (1)	TA2-M-SMA: 'We have behaviour problems as well to deal with, so you know […] however the symbols are sometimes very difficult to understand […] if the poem is using old English or words which are not frequently used or they are not familiar with this at all, you know not very clear simple words that means it's very difficult. Get bored and switch off.' T1-M-SMA: 'I suppose understanding vocabulary because seeing the students that we work with, even the brightest have limited understanding of the vocabulary.' T8-M-PI: 'We need to work on focusing their attention and getting them involved actively in the learning so they use learning partners. So, they are participating rather than sitting and listening' TA11-M-SP-CH: 'I think they have got severe speech and language impairments [..] we have to keep our sentences very short, back it up with signalong, back it up with a picture, a lot of emotional literacy […]'
Important Factors for Teaching SEN	**Teachers' beliefs about the teaching factors**	Visual and audio (12), Simplicity (5), Attractive layout (i.e. font, colour, design) (5), Resources are easy to use (1), Counting	TA2-M-SMA: 'Poems and jokes are the most difficult thing to go and translate at times [...] what we do in school, we use a lot of PECS symbols and also Makaton and then at one-point Makaton symbols are very important because we

Codes	Theme	Sub-Themes	Quotations from Transcripts
	Type of Resources (4), Reduce preparation time (16), Independency, differentiation (5), Mood, class management (2), Understanding (9), Group size (one-to-one or small group) (13), Communication (3)	the ability level (2), Design, style and type of resources (4), Attention and listening (3), Individual needs (2), Engaging (2), Vocabulary (1), Prepare text and images for each topic (2), Preparation time, support ASD, staffing	teach Makaton throughout the school, however the symbols are sometimes very difficult to understand' TA6-M-SR: 'You need the text more as well as the picture because some children with special educational needs they won't be able to like recognize if you just show them 'bed', they won't remember, so if you put like you know if you have a picture of a bed then you write it at the bottom' T2-M-P: 'I think you need to have the right resources, first of all, the right poems according to the student's levels and abilities'
Training	**Teaching staff experience with training courses offered in school** Trained (8), Untrained (13)	Staff trained from experience (1), not trained (4), Unaware of the symbol systems (6)	TA10-M-SP-CH: 'Yes you know I had Makaton, now we do signalong, I have done a behaviour management course, one year, and we do the training as it comes up'
Cognitive Load Awareness and Resource Preparation	**Teaching staff's thoughts about cognitive load and preparing the resources** Individual needs (3), Simplicity (2), Language (2), Resources (2), Group work (1), Behaviour problems (1)	Combine the options and present them in the same area (text, image, sound, symbols), simplify the content-short text (3), The design of the resources (1)	TA1-M-SMA: 'I think you need a combination of all of these concepts, I think you need images, symbols – we do relate them to text so I will be able to relate them to a particular word – but we combine all of these different ideas and visual cues to help students' TA7-M-SMO: 'Yes, long sentences won't work for them, they won't remember' A11-M-SP-CH: 'I think basically they have got severe speech and language impairments so for everything we have to keep our sentences very short'

Codes	Theme	Sub-Themes	Quotations from Transcripts
SENTP for Autism spectrum disorder) (ASD)	**Staff thoughts about whether SENTP can have a significant impact on teaching ASD students:** Visual (3), Combination of resources (11), Emotion (2), Symbols (1), Class management (1), Communication (1), Availability (1), Preparation (1)	One-to-one support (1), Can Express Emotions (1), Support untrained staff (1), Support severe autism (1), Better communication (1), Vocabulary (2)	T8-M-PI: 'I think that is what I said before. It's from my experience [...] Working in a mainstream school [...] I think it could be developed for working with children with speech and language difficulties. Such as children with English as an additional language. And then possibly the sort of feeling, the emotion side of it, for specifically the autistic children' T4-M-SR: 'For autistic children, it probably would be quite useful' TA7-M-SMO: 'Yes, I think in my class, it would be autism […] they participated in it as you could see; they've been all sitting quietly'
Poetry	**Staff beliefs about using poetry as a material for teaching** Difficult to understand (4), Good Teaching Material (5), Interpretation Required (2), Required Expression of Emotion (1)	Simplify the lesson (1), Difficult to understand the underlying meaning (1), Visuals are essential (2), Challenging (1), Figurative language (2), Imaginary and inference is greater (3), Interpretation (2)	TA2-M-SMA: 'Poems and jokes are the most difficult thing to go and translate at times' T4-M-SR: 'For autistic children, it probably would be quite useful' T8-M-PI: 'I think with poetry, it is that understanding, I think the inference is greater and the imagery, so there is more interpretation with poetry […] it can be because the vocabulary used is more difficult and also the figurative language'
SENTP Evaluation	**Teachers' beliefs about the SENTP** Aid for Individual Needs (7), Preparation Time and Effort (13), Class Management (14), Reduce/Replace Resources (20), Enhance Teaching and Learning (21), Benefit Autistic Students (5), Engagement (10), Resource	Reduce Resources (19), Replace resources (1), Increase motivation (14), Increase engagement (10), Increase concentration (4), Save preparation time (12), Better class management (14), Support different types of SEN-ASD (5), Visual learners (4), Hearing impairments (1), Mood (4), ADHD (1), Reduce boredom (3), Frustration (1), Physical special needs (1), Support speech	TA8-M-SMO: 'It would be better with moderate learning difficulties. We are severe learning difficulties' T4-M-SR: 'It would, yes especially because you have all the multi-sensory, you've got your sounds, you get visual aids, so it would definitely helpful' [….] 'It will basically include all the children so you don't have specifically go and look for resources, it will help the planning quite a lot, we don't have to look around for visuals if you've got the sound and everything in one place, so you're ready and can go as soon as you need it' [….] 'For autistic children, it probably

Codes	Theme	Sub-Themes	Quotations from Transcripts
	Availability (4), Support Teaching staff (21), Understanding (2), Behaviour Problems (13), Availability (3), Support Different Groups of SEN (4), Easy to Use (7), Communication (7), Simplicity (2), Effective Lesson - with combination of image, text and/or symbol (10), Better Teaching Results (12), Reduce Split Attention (10), Design (8)	delay (1), Replace teaching, staff (3), Reduce teaching staff (8), Reduce pressure on teaching staff (11), Available any time (3), Support group (4), Better understanding (1), Effective teaching tool (3), Simple instruction required (11), A tool that can be chosen in the future (21), Offer independence in facility use (1), SEN impression of the idea (5), Interesting idea (21), Simplify the topic (1), Support when short of staffing (6), Offer successful delivery of poetry lesson (5), Support untrained staff (9), Support children with additional language (2), Offer efficient way of teaching when presenting a combination of image, text and/or symbol in the same area of the screen (5), Enhance SEN teaching/learning in: Science (2), Maths (3), Humanities (1), Storytelling, literacy (1) and special projects (1)	would be quite useful' […] 'It will definitely help the child to understand the poem, interacting a bit more' TA2-M-SMA: 'I think for the learner or the student it would give them a faster understanding and take away quite a lot of frustration of not understanding and take out the boredom of not understanding until one of them has understood […] well, you can use it for counting, mathematics and you know RE, you can use it for history, so yes you can apply it to another subject' […] 'Yes, especially if they can go and use the equipment themselves' […] 'combining pictures with sounds with text so more of combination' TA1-M-SMA: 'Yhaa I mean we use writing with symbols, text, the software symbols here all the time, and anything that gives you a symbol or an image link to a concept, that is extremely important, so yes indeed' TA6-M-SR: 'Yes because I like that. It makes it look simpler. Yes, I would' T2-M-P: 'I think it was good, I enjoyed the session and I am sure the children did too' TA12-M-SP-CH: 'No, that is fine, really, I think it good idea to teach children in different ways, of course I am looking after children here according to their needs but obviously if you are with older mainstream children this prototype does help them'

Table 6.6: Codes, Themes and Subthemes

Current Teaching Methods:

During the interviews, participants identified various ways of teaching poems using either computers or manual methods. Observations revealed that a wide range of media content is used by teachers, including images, flashcards, symbol cards, props, sign language, readymade packages, sounds, or designed resources by the teaching staff. The resources are chosen according to the students' needs and age because as individuals, each learner has a different learning style with different understanding and unique experiences of the world (Sajadi and Khan, 2011). All the resources used for special needs are visual which is confirmed by all the interviewed participants. For example, the comments from the teaching assistant, TA9-M-SP-CH, from the nursery school of speech and language difficulties confirmed that all her teaching resources are visual: '*All the resources are visual and it does help'***.** Moreover, all the participants claimed that they prepare all the resources required for each lesson as commented by TA1-M-SMA from the special secondary school *'We make a lot of our own resources'*. The same point confirmed with statement from the teaching assistant, TA12-M-SP-CH from the special nursery school '*Yes, we prepare everything [teaching resources] here*'. Understanding the current teaching methods is useful in designing/refining the proposed framework and comparing the teaching results derived from current methods in comparisons with SENTP.

Current Concerns in Special Needs Schools:

Many participants described their experiences when expressing current teaching concerns. They highlighted issues such as a lack of attention, individual needs, behavioural problems, preparation time, engagement, student independence, understanding teaching materials, reading, physical movement, understanding emotional language, and communication difficulties and the staffing demand. For example, the participants discussed staff shortages when teaching with current resources, seen in T7-M-SMO's statement: 'I know that most of the students need kind of one-to-one […] Ideally, all our students deserve one-to-one, but that is not possible'. T8-M-PI said that preparation time was a concern: *'Certainly, I think preparation is an issue because it is just a time factor [...] our teaching assistants and teachers are* *very good at preparing additional resources for special needs children, but it is very time-consuming'*. Other teaching assistant from the same school, TA1-M-SMA strongly agreed on the same point: *'We make a lot of our resources'*. On the other hand, TA9-M-SP-CH responded to confirm that attention and behaviour are essential aspects for student understanding in class: *'Yes, because it's the attention and the behaviour'*. TA12-M-SP-CH, the teaching assistant from the special language and communication difficulties pre-school emphasised that improving student understanding can increase students' engagement and concentration: *'it [engagement and concentration] depends on the understanding. If they understand, then you grab their attention'*. The teachers have different types of students each year at different levels which force them to prepare different resources every year. This demand effort and time as noted by the teacher from the special school T1-M-SMA: *'yes because every year class ability changes and what children like […] and that is why we special needs teachers really difficult job, creating resources, because we have to start pretty much start from scratch every year when you look at a new class you have got each year'*. Finally, one of the important concerns for the teaching staff is the students' communication and development of their vocabularies as noted by T1-M-SMA: '*I suppose understanding vocabulary, because seeing the students that we work with, even the brightest have limited understanding of the vocabulary'*. This theme is important in identifying participants' requirements and assessing if the SENTP can reduce the staff concerns.

Important Factors for Teaching SEN:

Some participants commented that resources should be visual, as indicated by TA7-M-SMO: *'Images are best for our students because they can understand pictures, but not everyone can read; only one person can read'*. Another view is from T4-M-SR: '*Basically, if there are visual pictures for them to see, then it would definitely be helpful'*. Other participants emphasised using more than one resource, like TA6-M-SR: *'You need the text as well as a picture, because some children with special educational needs won't be able to recognise anything if you just show them the text 'bed'; they won't remember, so if you put a picture of a bed, then you write the word at the bottom'*. Student levels and abilities are among other important issues raised by participants as comment by T2-M-P: *'I think you need to have the right resources, first of all; the right poems, according to the student's levels and abilities'*. Moreover, from analyzing the interview data it is clear that the current teaching methods require time, preparation, and should ideally be visual. Participants signposted the current teaching requirements during the interviews by expressing their concerns and the main issues involved in teaching SEN. A key issue that emerged was behavioural problems, which was mentioned on numerous occasions. Class management relies on student understanding and on increasing their attention and the concentration. This was indicated by TA10-M-SP-CH: *'If they can't concentrate much, apparently, they are not learning, and they are disturbing others as well'*. TA7-M-SMO: impose the same view *'Classroom management depends on the kids; it depends on their behaviour in the lesson'*. This theme is important to show the important factors for teaching special need student in order to understand the students and staff requirement and to assess if the SENTP can apply positive impact on these factors.

Training:

Training is important to both general teaching as well as change realization. Most participants had completed a 'SENCO' course and had experience of working with SEN. However, some participants had no chance to do any PECS, Makaton or Sign language training cources. This lack of training has an impact on the quality of teaching of students with special requirements, such as students with varying levels of autism. Some of the participants were unfamiliar with any of the symbol systems as noted by TA9-M-SP-CH said: *'I don't even know what Widgit and PECS are'*? Also, the transfer of teaching staff or students from one school to other could cause problems as each school follows a specific symbol system to teach its students. Such responses necessitate a system to help untrained staff to manage and enhance their teaching.

Cognitive Load Awareness and Resource Preparation

All the factors are related to awareness of cognitive load. Most participants had very little knowledge of the SEN cognitive load effect, while few had some knowledge and they consider it when they prepare their resources. The participants with some knowledge of cognitive load (CL) believed that CL could be reduced by understanding the ability of the students as shown by T7-M-SMO: '*Yes, we should take into consideration every individual pupil's ability to access what we are presenting'*. The participant at the severe special needs school commented on the same issue: *'In special need schools, and in M-SMO (special school name), every single student has an individual work plan which is a key stage scaled for them, and that is how we know our students so well because we adapt the curriculum to specific students and each student's ability'*. Simplicity and combining resources were among the most important points indicated by TA11-M-SP-CH: '*They have got severe speech and language impairments, so we have to keep our sentences very short, back them up with sign-a-long language, back them up with pictures, and we have to do a lot of emotional literacy; those are things we have to do all the time to support them in any area'*. Moreover, some of the teachers suggested combining different media can improve understanding, by the reduced cognitive load, as noted by T1-M-SMA: *'I think it would have been good if we had sound as well as there is a picture'*. Consequently, it is important to understand CL when teaching SEN.

Poetry

All participants agreed that poetry is a useful vehicle for teaching but constitutes challenging material for special needs children because of the difficulty in understanding the underlying meaning and the broad vocabulary. The teacher from the primary school, T8-M-PI described poetry as *'a figurative language in which you can talk about emotions and use imagination'*. T8-M-PI added that concentrating on poetry is a great tool for teaching, despite the difficulty in understanding some of the words: *'Poetry is great vehicle because there is a lot of imagery in it, but it's not written clearly; it's not matter of fact, like a football match report or something like that, reporting the facts. Poetry is about impressions, and it is about emotions, it is about feelings'*. Furthermore, some participants said that teaching poetry requires a lot of visual aids, as commented by TA5-M-SN: *'We always need visual aids. We see good concentration when there are visual aids but if you say something, just talking, they don't concentrate'*. Positive results from the testing of the SENTP show that it can support this challenging subject and to support individual needs.

ASD (Autism Spectrum Disorder)

There was considerable agreement among participants across the teaching staff that, autistic children find learning difficult if it involves emotions, underlying meanings, and imagination. This concept was expressed by T8-M-P: '*Poetry is about impressions, and it is about emotions, it is about feelings. The thing that they find particularly challenging is emotions, feelings, and inference. The inference is very tricky for them'.* This seems to indicate that poetry is a difficult topic to understand for autistic students. The participants expressed a view that the SENTP could benefit their students; T4-M-SR commented: *'For autistic children, it probably would be quite useful'*, and T8-M-PI touched on the need to express emotions in poetry for students with autistic: *'Based on my experience, [...] working in a mainstream school […] possibly the sort of feeling, the emotional side of it, [is beneficial] specifically for autistic children'*. Furthermore, T8-M-PI emphasised: '*I think certainly developing your emotional vocabulary and the content in that area […] would work very well for autistic children because that is what they have difficulty with, and the problem is that they have difficulty interpreting visually anyway*'. This result shows that SENTP can be an effective teaching tool for autistic children.

SENTP Evaluation

The evaluation shows that SENTP within the SEN domain makes significant contributions towards SEN teaching and learning. One of the most important visits was to the special needs secondary school where a demonstration was conducted by T7-M-SMO. His class was a challenging group, with different levels of severity of special needs. These problems were autism, ADHD, Asperger's syndrome, behavioural, emotional, and social difficulties (BESD, formerly EBD), severe learning difficulties (SLD), and some mixed symptoms. The teacher presented the class with four poems, asking students if they wanted more content after each poem, instead of teaching just one, as agreed with the teacher before the lesson. The immediate feedback from the students and the teacher reaction demonstrated that the entire class was engaged and motivated during the demonstration as noted by T2-M-P: 'They were well involved, they can take part with their actions, with their hands, fingers, very engaged and looking at the computer screen and watching all the images, very involved' and part of the email sent by T7-M-SMO '. In consultation with the class staff, it was felt that the session was very successful. This was made clear by the high level of pupil engagement during the lesson […] the design of the prototype shows promise' (see Appendix B). Also, TA8-M-SMO expressed her concerns about some children that they may lose attention because of their physical disabilities and the traditional way being used to teach them: '*It does make it easier because our children will not have the ability and understanding of turning pages because they lose their attention, their attention is only a couple of seconds[…]'*. This shows that SENTP can enhance the concentration and engagement of SEN students with physical disabilities.

Using the SENTP encouraged group work as well. The class teacher from the special secondary school, T7-M-SMO reported that he will suggest group work for his class in addition to the current approach of independent learning as the headteacher attended and observed the demonstration and found that the demonstration was successfull: '*our English and maths is usually done at workstations and I think there is space for group work as well; they work very well [SENTP demonstration]'*. He confirmed that in his email when he said, *'The prototype could be used for target groups during teaching and would be a valuable resource when finalised'*. This shows that SENTP can support group work to reduce the one-to-one staff demand and to overcome the difficulty in learning with others in small or large group settings.

Furthermore, the tool was shown to be useful for class management, as indicated by T1-M-SMA, a teacher in the special secondary school. Her class includes children with a mix of severe issues and she has good background experiences: *'We have children with severe learning difficulties, including children with Down's syndrome. I have experience teaching autistic children; we also have children with genetic disorders and severely challenging behaviour; we have a huge range of children*'. T1-M-SMA commented on classroom management: *'All the students were quiet and listened when the lesson started'*. This shows that the SENTP supports teachers with managing special need classes that they can be easily distracted with behavior problems.

All the participants agreed that visuals are important to SEN. TA11-M-SP-CH indicated that the image annotation within the SENTP can improve engagement and attention: *'It's visual, isn't it? It keeps their attention'*. TA12-M-SP-CH indicated that having different options for annotation types can offer various types of teaching methods: *'They give a broad range of ideas and thinking, and we can use different ways to teach children'*. This point was furthered in an email sent by TA7-M-SMO '*The ability to have instant access to images etc. and not have to rely on on-the-spot searching would contribute to the pace of the lessons and thereby minimise anxious behaviour and increase understanding'*. Hence, SENTP can reduce the student cognitive load because it increases attention and understanding to overcome the struggle of any special need students with their poor auditory memory problem.

Most of the participants pointed out that the annotation included within the SENTP is fun and interesting, as indicated by TA1-M-SMA: *'I think it is quite engaging; children enjoy looking at the images in the classes'*. TA7-M-SMO agreed: '*Actually, the student sitting next to me actually participated because he was signing [using sign language] what he saw, what you said [...] he seemed to be enjoying it, so yes'*. T2-M-P said: *'The session went quite well. It was very easy-going, the children really enjoyed it, and I think they benefited from it'*. SENTP can reduce a behaviour problem which is one of the main concerns in teaching special needs. SENTP could reduce student frustration and improving their mood as noted by many participants and TA2-M-SMA is one of them *'It [SENTP]takes away quite a lot of the frustration of not understanding [...] It takes out the boredom of not understanding until all of them have understood'*. These benefits of the SENTP are of particular importance in reducing behavioural problems of special need students as they tend to have low tolerance levels and high frustration levels.

All the participants agreed that the SENTP could be adapted to subjects other than poetry such as RS, science and maths, as indicated by T1-M-SMA: *'I think it is really good; that is what I am left with today. That the concept of a click in the text and it pops up with a photo is very good, something we could use for poems, for all kind of things, anything that has text'*. This demonstrates that SENTP can be utilised in teaching different learning content to support SEN students such as the one who struggles with their poor handwriting skills and the difficulty in following complicated directions or remembering directions for extended periods of time.

The teachers consider the SENTP as an ‘easy to use’ tool, which TA12-M-SP-CH touched on: *‘Yes, I would like to use it because it is the simpler way to teach and grab children’s attention, and [it works] on different levels for different children*’. This demonstrates that SENTP can make the teaching content simpler.

Many participants mentioned that the SENTP saves preparation time; TA7-M-SMO said: *‘It’s good and we can concentrate on assessing more students because, you know, we have to assess them’*. This shows that SENTP can save the staff time and effort to free them for other significant work.

Figure 6.10 illustrates that three participants believed that SENTP is valuable tool because it can be available anywhere, and anytime.

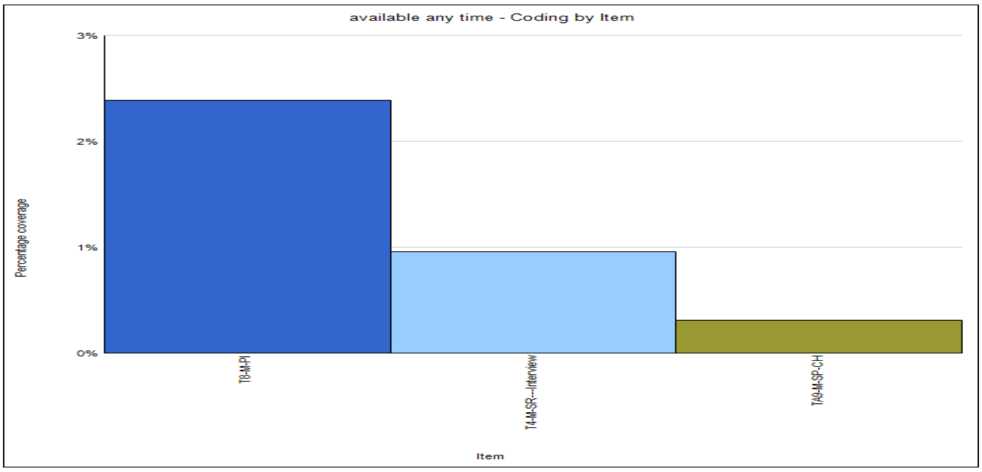

Figure 6.10: Results of SENTP Availability

Other points related to the ability of the SENTP to support the teaching staff were noted by by all the staff and the headteacher of the special secondary school, who said *‘I think the speech therapist would be very interested to see this software’[..] ‘It’s interesting’*. Figure 6.11 presents a graph to show that SENTP can save preparation time. The feedback from the interviews showes that the SENTP can help teachers by replacing the teaching assistant in particular tasks and reducing the job requirements of academic staff, as illustrated in Figure 6.12

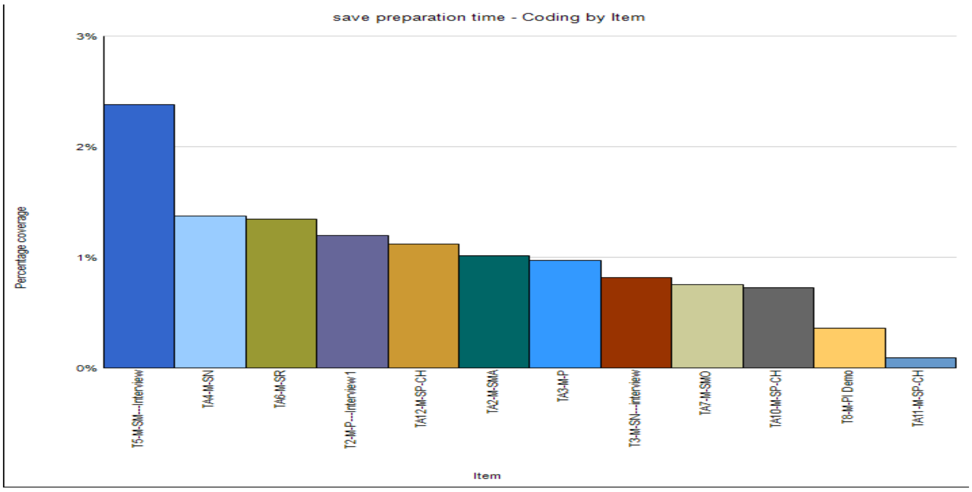

Figure 6.11: Perception of Participants that SENTP Saving Preparation Time

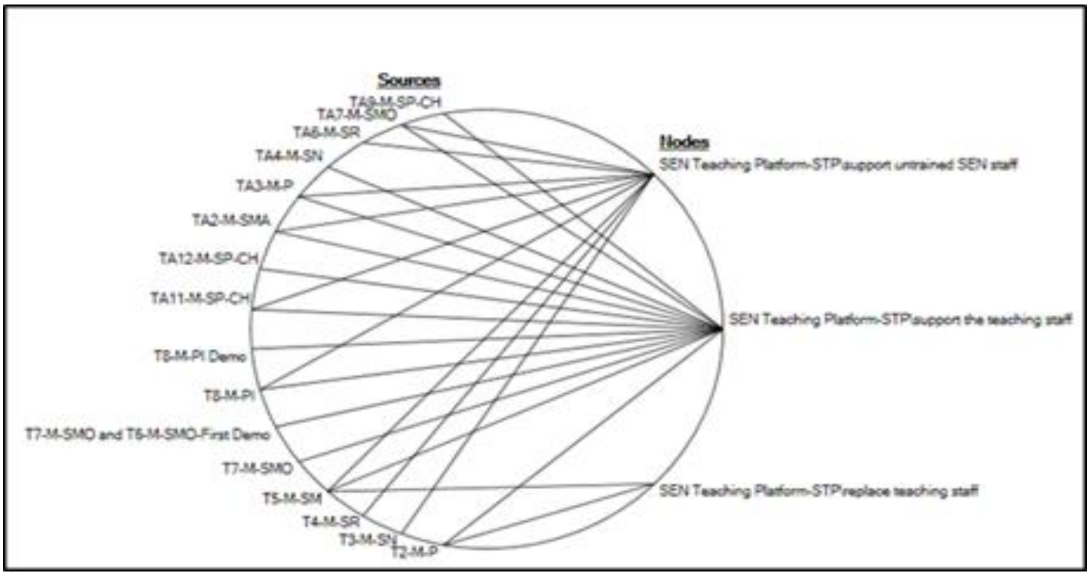

Figure 6.12: Participants Evaluation on SENTP in Supporting Teaching Staff

Considering outcomes from the field test generally, the participants were in agreement that the SENTP can: 1) enhance the teaching and learning of special needs students with better understanding; 2) reduce their behaviour problems, 3) increase their concentration and engagement; 4) replace or reduce the need for traditional teaching resources; 5) be adapted to aid in all the subjects for all SEN issues; 6) be a very reliable tool for group work which is lacked in some schools; 7) increase student motivation, improve understanding of underline meaning and emotional language, and; 8) support teaching staff with routine preparation and limit the demand for more staffing. The findings reveal that all participants would be happy to use the SENTP in the future, as commented by the teacher from the special school T1-M-SMA: *'Yes, happy to use in the future, but it has to be designed specifically for what subjects we are doing*'. TA7-M-SMO noted that SENTP is a valuable source to use in future *'Would be a valuable resource when finalised'*. Table 6.7 illustrates the accomplishments in iteration three. The table lists the user requirement for iteration three, all the current difficulties when teaching special needs with existing methods, the evidence from the interviews to confirm the previous point and evidence from the participants' transcipts that SENTP can enhance special need learning. (See Appendix F for more evidence)

Requirements	Current Teaching Methods Difficulties	Interview No	Evidence of Acheivement
1. The user interface (UI) should limit SEN students' communication and language difficulties, including English as a second language.	T8-M-P: 'I think it is the vocabulary very much [….] We worked on simplifying the language and making really show that the children really understand vocabulary that is being used and, also for special needs children when they work in literacy, the emphases are on inferential understanding.' TA11-M-SP-CH: 'I think basically they have got severe speech and language impairments.'	Interview 17,18, 19 20, 21, 30	**SENTP can support communication difficulties including languages and English as a foreign language** T8-M-P 'I think it could be developed for working with children for in speech and language difficulties [...] such as children with additional language.' T8-M-PI '[…] using rich vocabulary to support them, but this tool would equally do a similar kind of thing to that.'
2. The UI should be improved to increase students' engagement and reduce behaviour problems during the teaching process. In this way, SENTP can support students with ADHD issues.	T8-M-P: 'We have a number of children with ADHD and that will affect the focus and concentration in class because they are very distracted and so we need to work on focusing on their attention.' TA11-M-SP-CH: 'With severe speech and language impairments attention has to be the first thing, if they are not listening they can't learn anything else.'	Interview 11, 13, 14, 20, 21, 22, 23, 24, 26, 28, 30	**SENTP increased engagement and reduce behaviour** T2-M-P: 'The children really enjoyed it and I think they benefited from it, they were well involved, they can take part with their actions, with their hands, fingers, very engaged and looking at the computer screen and watching all the images, very involved.' T4-M-SR: 'It would if it gets concentration really well, if you will get multi-sensory then yes, it would increase the motivation' TA9-M-SP-CH: 'There is something visual there they could see even it is the first time they were looking at it, so they were quite engaged I thought so, yes […] yes, they were quite engaged, yes and because it is the first time they had more attention.'
3.The UI should improve SEN understanding, including the underlying meaning of words	T8-M-P 'The language of the poems is difficult to understand and see behind the lines. For example, if you click on bedtime you will see picture of bedtime, go upstairs, you will see a picture of going upstairs to bed, and	Interview 11, 13, 22, 23, 27	**SENTP can improve SEN understanding including the underlying meaning of the words** T2-M-P: 'We tried to aid that with pictures like you just showed us today and we find that is very helpful way for the children to understand it.'

Requirements	Current Teaching Methods Difficulties	Interview No	Evidence of Acheivement
	see the bed and talk about the colour of the bed, different styles of beds.' TA2-M-SMA: 'I think poems and jokes are the most difficult thing to go and translate it at times in the rhymes they use words which are not always used every day hence make it more difficult to go and translate it to a level. '		T4-M-SR: 'I don't think, it will definitely help the child understanding the poem, interacting a bit more' […] 'you would yes, you will have children know about the world and they will have better understanding.' TA12-M-SP-CH: 'Well, children with physical special needs, eye sight weak or understanding is not as good. They can understand better.' TA2-M-SMA: 'It would give them a faster understanding and, also take away quite a lot of frustration of not understanding and taken out boredom of not understanding until one of them has to understand.' T8-M-PI: 'It's getting them to understand the poem. I think it will be really really good to have some emotions represented on it that would work very well for our children because very often there is a lack of understanding of emotions and feelings, which is barrier to making further progress.'
4. The system should save preparation time, support staff with classroom management, help untrained staff (e.g. more resource availability)	T8-M-P: 'I think certainly preparation is an issue because it is just a time factor umm our learning assistant and teachers are very good at preparing additional resources for special needs children but it is very time consuming.' 'A lot of children with ASD prefer visual learning style which encourages the teachers and teaching assistants to prepare all the resources using images.' (Glazzard et al. 2010)	Interview 10, 14, 17, 19, 20, 21, 22, 23, 30	**SENTP can save the teaching staff preparation time, support with classroom management, untrained staff and resource availability** T1-M-SMA: 'I think it really support it.' (management) T2-M-P: 'Yes because we don't need the internet.' (availability) T4-M-SR: 'It would help definitely inexperience assistants' […] 'it will basically include all the children so you don't have specifically go and look for resources, it will help the planning quite a lot, we don't have to look around for visual if you got the sound everything in one place, so your ready can go as soon as you need it- management and availability.' T8-M-P: 'I think it is in the sense of giving an immediate feedback […] then that going to cut down on preparation time.'

Requirements	Current Teaching Methods Difficulties	Interview No	Evidence of Acheivement
5. The UI presentation should have clear information, real images, large font sizes and bright colours.	TA1-M-SMA to T1-M-SMA 'Sorry when you did some scanned images about the book.' TA5-M-SN: 'Pictures yes or photo and from the environment some examples.'	Interview 14, 16, 17, 19, 21, 22, 23,24, 25, 26, 28, 30	**SENTP can support the teaching and learning of SEN with images including real images** T7-M-SMO: 'The images would be more beneficial.' T8-M-P: 'The images only would work [...] for instance where a child really didn't have the language [...] The linguistic understanding. Then simple visuals could be effective... It would be very useful on both with maths, vocabulary [...] which a lot of children find difficult. Science and humanities.' TA11-M-SP-CH: 'Its visual, isn't it? So, it keeps their attention, yes I should think so.'
6. The system should be easy to use, edit and maintain to avoid any technical issues.	T1-M-SMA: 'Yes, and it is incredibly time consuming for us to do it'	Interview 10, 22	**SENTP is preferred to be simpler** T1-M-SMA: 'I think it needs to be a bit simpler.' TA11-M-SP-CH: 'It simplifies the task because it's a visual backup with the word.'
7. The SENTP should have the potential to benefit different subjects.	TA1-M-SMA: 'No but actually because a lot of time we need to create resources that is specific to the topics that are taught in class so we have to personalise the power point and make them appropriate for our children across the school.'	Interview 10, 11, 12, 14, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 30	**SENTP can be adapted for different subjects** T1-M-SMA: 'I was thinking of science, and you know like if you would like to do forces.' T2-M-P: 'Sure yes to support other learning topics.' T5-M-SM: 'Like maths, show the numbers, shapes.' T7-M-SMO: 'Absolutely, it obviously depends on the target group, but yes I think it can support, yes.' T8-M-P: 'I really think you could use it across any literacy activity.'
8. the annotations displayed on the UI should be presented as a	TA10-M-SP-CH 'You know even whatever topic we go it is so visual.'	Interview 11, 16, 17, 19, 20,	**SENTP can reduce Split Attention effect**

Requirements	Current Teaching Methods Difficulties	Interview No	Evidence of Acheivement
one learning source such as image and text or symbol cards and text		22, 23, 24, 25, 26, 27, 28, 30	T2-M-P: 'Probably would be image and information, wouldn't it because we have got two together which are link very well' […] 'I think you need that little bit of the combination [....] I maybe hearing impairments because you've got the images there and they can see it when you talking to them.'[..] 'If they have hearing impairments. The combination would be great for them.' T3-M-SN: 'Yes combining. If you want to pass message to the child it is nice to combine.' T4-M-SR: 'Symbols, images and text would be helpful, yes.' T7-M-SMO: 'I think that would be quite useful with a range of learners with learning difficulties, I mean because I mean our school its quite different from other schools, but I can see the benefit of that.'
9. Each page should be introduced as one source, rather than many replicated sources. Hence, one source can include image, text and information (addressing the redundancy effect and the coherence effect)	TA1-M-SMA: 'At the moment, what we do in power point is scanned image of that book and we would link with a sound or a video, so when we say ocean may be a video clip about ocean and they see a picture or a video of ocean.'	Interview 11, 13, 16, 19, 20, 22, 23, 24, 30	**SENTP can reduce redundancy effect** T2-M-P: 'I worked with a child where I used Makaton, so Makaton was very helpful that is not in the setting of course it was in different setting, Makaton we used as well as like images and information would be beneficial I think.' T4-M-SR: 'It would, yes especially because you have all the multi-sensory, you got your sounds, and you get visual aids so it would definitely helpful.'
10. Each page should be presented as a source with combined learning material such as visual (image, symbols) with sound (the modality effect)	TA1-M-SMA: 'At the moment, we would link with a sound or a video, so when we say ocean may be a video clip about ocean and they see a picture.'	Interview 10, 12, 19, 20, 22, 25, 30	**SENTP can reduce Modality effect** T1-M-SMA: I think it would have been good if we had sound as well as there is a picture' T3-M-SN: 'It is good if you add sounds.' TA10-M-SP-CH: 'Yes, if they were going to use it and obviously its good combination, it's got sound, Makaton there.' TA9-M-SP-CH: 'Yes, I am thinking about our kids. Visual and sound, two things together it works well.'

Requirements	Current Teaching Methods Difficulties	Interview No	Evidence of Acheivement
11. The system should support or replace manual teaching methods, such as symbol cards.	TA11-M-SP-CH: 'We have general things to use all the time. Lot and lots of pictures, cards and visual symbols, visual time tables, we use sign a long.'	Interview 13, 14, 21, 22, 23, 24, 25, 26, 27, 28	**SENTP can reduce and support the current manual teaching methods** T4-M-SR: 'It does reduce other resources if you got everything in here.' T5-M-SM: 'Yes it will reduce […] I think it will replace.' TA1-M-SMA: 'I think it could be a supportive aid to some of the software. I don't think it would replace it but it would be just support it.'
12. There should be the option of displaying visual materials (images, symbol systems) while staff verbally demonstrate the system, or use headphones along with the visuals	TA5-M-SN: 'Visual, I think and sometimes you find child have problem with speaking, we had rhymes with visual aids.'	Interview 13,24, 25	**SENTP can reduce Contiguity effect** T4-M-SR: 'Images only if you are using your voice, visual with auditory combination then yes but images only would not be enough, yes to combine' TA3-M-P: 'The one you done today, it was quite good one. Yes, I like this one so they can see the picture of the monster'
13. It should be possible to explain at the beginning of the lesson how the system works and to provide pre-training (the goal-free effect).	R: and they like the routine, specially the Autistic? T7-M-SMO: 'Ohh, yaa.'	Interview 10, 13, 14, 19, 22, 24, 27, 30	**Goal free effect can be reduced by explaining at the beginning how to use the SENTP** T1-M-SMA: 'I think just briefly yhaa.' T4-M-SR: 'Yes it would be better if we briefed on how it works and how we can use the too.'
14. The system should be able to support students with differing severities of autism	T7-M-SMO: 'No, I don't. I think the way that we present poetry and stories are supported with object of reference, images, and sounds.'	Interview 13, 16, 17, 24, 28	**SENTP can support autistic students in teaching and learning process** T4-M-SR: 'For autistic children, probably would be quite useful T8-M-P 'The sort of feeling the emotion side of it for specifically the autistic children.' TA3-M-P: 'Maybe the children like Autism.'

Table 6.7: Requirements with Results

However, the teaching staff also offered some ideas to further develop SENTP in order to gain additional benefit. Some of the suggested developments on SENTP refinements which can be undertaken with Semantic Web tools is on encouraging student independence as noted by T8 and T6. T6-M-SMO, who teaches a class with severe learning disabilities, believed that the SENTP could be adapted to younger ages and is currently more suitable for special needs students aged 4 to 19. T1-M-SMA added that a video or animation could improve the efficiency of the SENTP in fulfilling different needs. Also, the second study of this research suggested that it can support students with English as a second language as noted by T8-M-PI: *'Support English as additional language, because it quite graphical'*. Figure 6.13 is a screenshot of all the suggested thoughts from the participants for the SENTP future development.

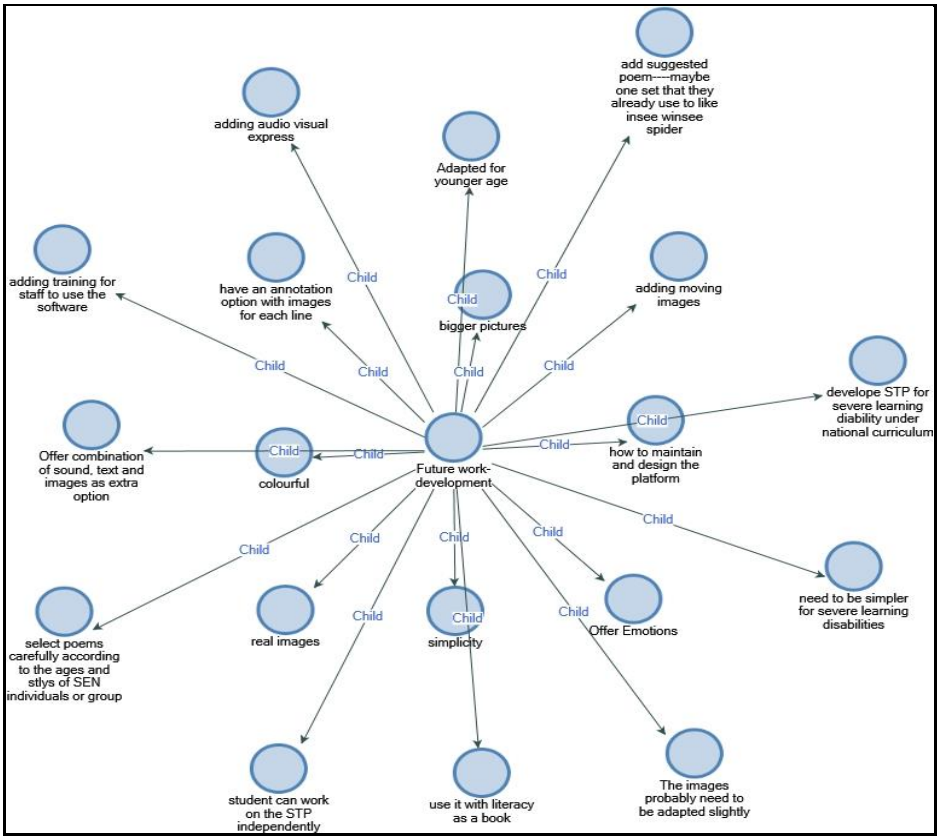

Figure 6.13: Recommendations for SEN Further Improvement

6.10 Emerging Design Blueprint

A design blueprint is used to articulate the evolution of artefacts overs the course of this work. It provides a generalised set of processes required for the annotation of SEN teaching material, linking specific interactions to roles and content. Interaction between students, educators and technology is presented in a chronological manner for greater understanding (see Figure 6.14) (Kalbach, 2016). It can be seen that semantic web annotation underpins the design phase (see the support process in Figure 6.14), enhancing the learning experience of special educational needs students. The blueprint is also used to articulate the interaction between various service users (student and designer/teacher). Figure 6.14 depicts a SENTP service blueprint, illustrating the interaction between student and teacher/activity designer. Students start an activity (opening the SENTP application), selecting teaching material and viewing the annotated teaching material independently. Students listen and interact with an educator before being tested using a worksheet. The learning and learning material assessment is completed by the educator using a range of methods such as feedback, Q&A or observation. Observation approaches are the preferred method for gathering information about the learning of pupils who can use non-verbal or pre-verbal forms of communication (European Agency, 2015).

Teacher/designer actions start by scheduling the activity and then preparing an activity draft, for example a list of poems. Existing media elements are chosen to be embedded within selected teaching material – with selections based on SEN student requirements. The result is an annotated webpage used by students with a specific need. The link between activity, annotation and SEN is encapsulated with the ontology and provides a means to select appropriate commentary of blueprint.

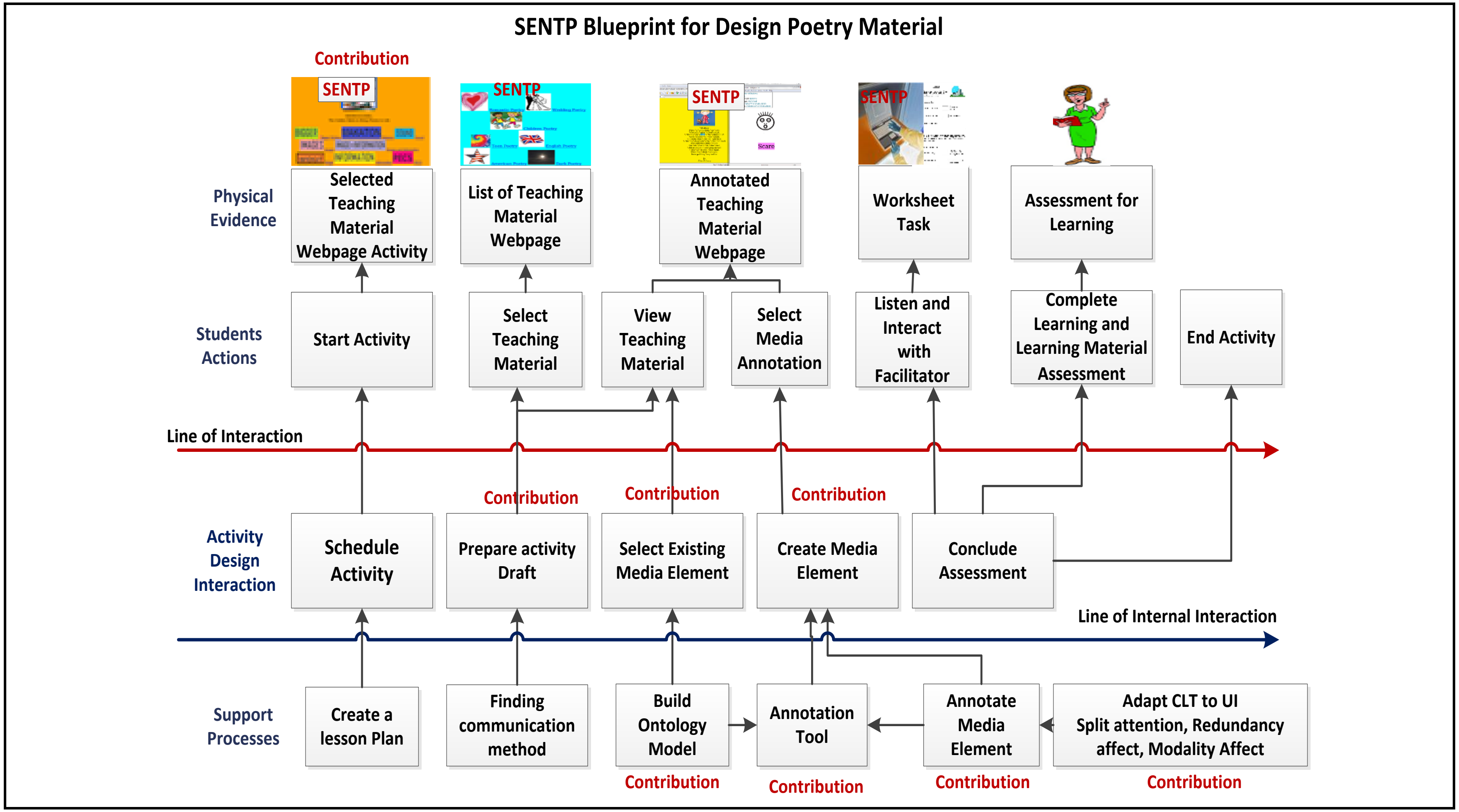

Figure 6.14: SENTP Blueprint

6.11 SENTP Blueprint Ontology Building

In the Semantic Web, domain ontology is a main resource for semantic annotations. Ontology is defined as formal and explicit specification of shared conceptualization (Gruber, 1993). A conceptualization can be understood as an abstract representation of the world or domain we want to model for a certain purpose. Figure 6.15 shows the overall architecture of the SENTP annotation process.

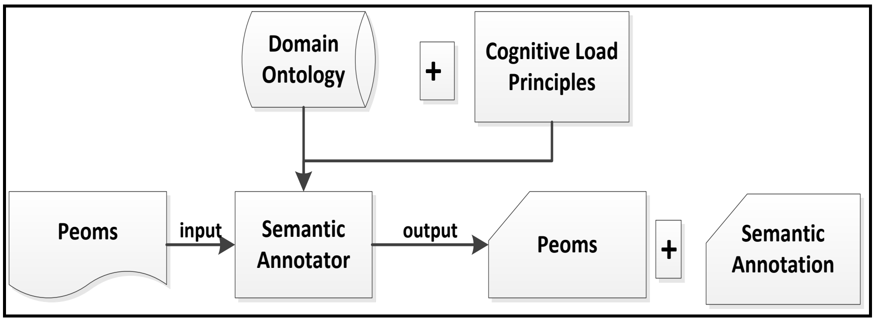

Figure 6.15: Semantic Annotation Process

The main goal of ontology engineering is to produce the desired ontologies for a specific purpose. Subsequently, the ontologies are put to work in several real-world application areas to help communication improvement between agents (people or software agents). Ontologies may differ, depending on the concept for which ontologies are designed and used. We would claim that the ontologies themselves are the products of design science research as ontologies are type of design artefact used to improve processes, such as solving Information Systems (IS) problems (Ahmad et al., 2012). In the literature, several kinds of ontologies have been investigated and evolved in an incremental manner. In the design-science paradigm, knowledge and understanding of a problem domain and its solution are achieved in the building and application of the designed artefact (Hevner, March, and Park, 2004).

This study illustrates the benefits and development of the SENTP ontology. Firstly, the ontology furthers the understanding of SEN learning domain and the interactions between teachers and students. Secondly, the use of the ontology for this research allows thorough analysis of SEN domain knowledge. Thirdly, the ontology concept model is needed to assist users to retrieve only the sites or documents that are most related to their query. The problem of unnecessary documents is solved by ontological concepts. Finally, the experience of students, the designer and educator gained over three iterations is used to design the SENTP ontology model where the annotation can be shared between the educators, students or designers.

Design science is an appropriate method for ontology research (Weber, 2002; Indulska and Recker, 2010). Regardless of the application areas in which ontologies are going to function, as long as ontology is used to address unsolved problems, and it makes a unique contribution to the context under consideration, then that ontology-based solution is relevant. In addition, if the use of the ontology to solve a given problem is novel within the given context, then that ontology based solution has met the key characteristic of DS research. Figure 6.15 shows a diagram of the SENTP ontology. The figure presents the key concepts that exist in the SEN domain, their properties and the relationships that hold between them. The SENTP ontology (Figure 6.16) shows the classes (as in Table 6.7) that are added to the relations, attributes, and instances described in Chapter 4.

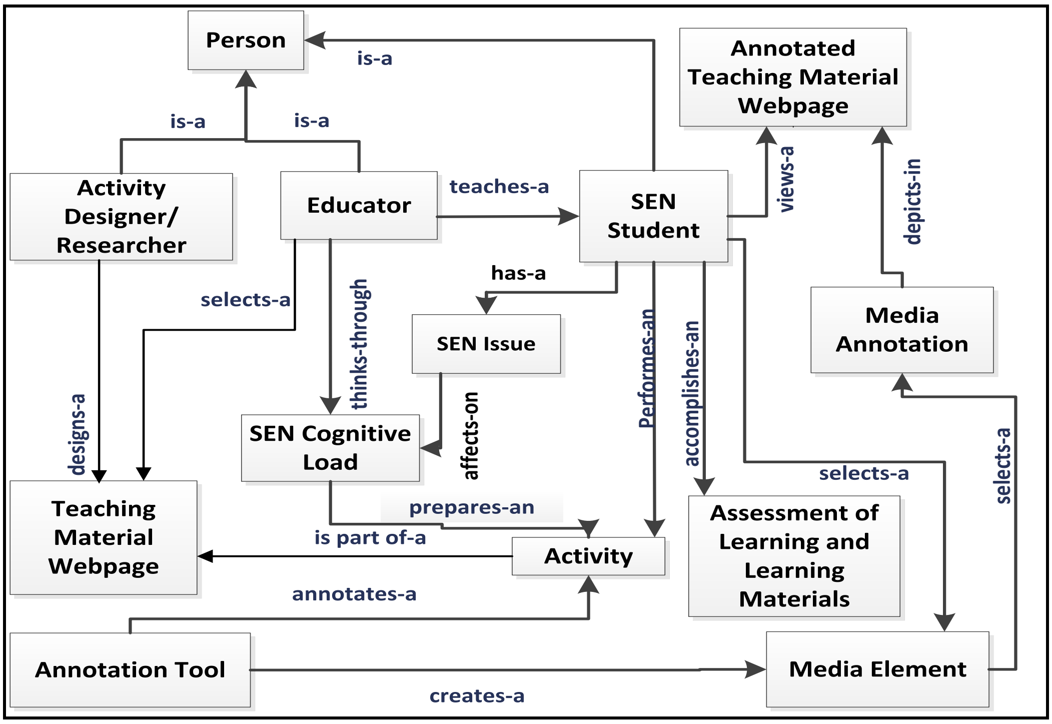

Figure 6.16: Extended SENTP Ontology Model Structure (Iteration 3)

Table 6.8 shows the definitions of each concept in the SENTP ontology. In addition, the set of relationships (i.e. properties) that connect the concepts are defined in Table 6.9.

Class	Definition
Person	Defines any person playing any role in the education process.
Activity Designer	Defines any person who is involved in annotating the teaching material, such as the researcher or the ICT school technician.
Educator	Represents all the teachers, teaching assistants and head teachers.
SEN Student	Describes the special needs students.
Teaching Material Webpage	Describes the teaching material webpage designed (E.g. HTML) which is part of the activity assigned to each student.
SEN Cognitive Load	Describes the students cognitive load effects that causes reduction of cognitive load.
Activity	Describes the activity prepared for each student.
SEN Issue	Defines different special needs issues such as Autism.
Annotation Tool	Describes the annotation tool required for the selected activity.
Assessment of Learning and Learning Material	Describes the assessment of the students learning and the learning materials.
Media Element	Describes part of the teaching material annotated using the annotation tool
Media Annotation	Describes the form of the annotation required for media annotation.
Annotated Teaching Material	Describes the annotated teaching material webpage (e.g. SENTP).

Table 6.8: SENTP Ontology Classes

Property	Definition
is-a	Describes the relationships between the parent class and subclasses (e.g. **Activity Designer, Educato**r and **SEN student** are all **Person**).
teaches-a	Defines the relationships between the **Educator** and **SEN Students** classes (e.g. Educator teaches a Student).
designs-a	Describes the relationships between the **Activity Designer** and the **Teaching Material** classes (e.g. Activity Designer designs a teaching material webpage for the selected topic).
selects-a	Describes the relationships between the **Educator** and the **Teaching Material** classes (e.g. the educator would select the Teaching Material Webpage for the teaching session). Also, the relationship between the SEN Student and Media Element as the student has an option to use SENTP independently.
thinks-through	Describes the relationships between the **Educator** and **SEN cognitive load classes**.
annotates-a	Defines the relationships between the **Annotation Tool** and **Activity classes.**
creates-a	Describes the relationship between an **Annotation Tool** and **Media Element** classes.
performs-an	Defines the relationship between **Student** and an **Activity** classes.
accomplishes-a	Describes the relationships between the **SEN Student** and **Assessment** classes (e.g. worksheet, Q&A. etc.).
Prepares-a	Defines the relationship between the **Activity** and **SENCognitive load** classes (e.g. Consideration to reduce split attention, redundancy effect and modality effect).
depicts-in	Describes the relationships between **Media Annotation** and **Annotated Material Webpage classes** (e.g. when selecting Makaton and presenting the annotated poems with Makaton annotation).
is part of-a	Describes the relationships between the **Activity** and **Teaching Material** classes (e.g. 'Bed Time' poem is part of the poetry Teaching Material Webpage).
has-a	Describes the relationships between **SEN Student** and **SEN issue** classes.
effects-on	Describes the relationships between **SEN Issue** and **SEN Cognitive Load** classes.

Table 6.9: Depicts the Relationships between the Classes

Examples of instances for an object or individual class of a SEN student is as follows:

has_name: Tommy, **has_date_of _birth:** September 26, 1990, **has_address:** 33 far_Road_HA5_8PK, **has_behaviour:** throwing-pens, screeming, **has_teacher:** Miss_Dona, **has_teaching assistant:** Miss Brown

Figure 6.17 illustrates extract of representation of the SENTP Annotation Model

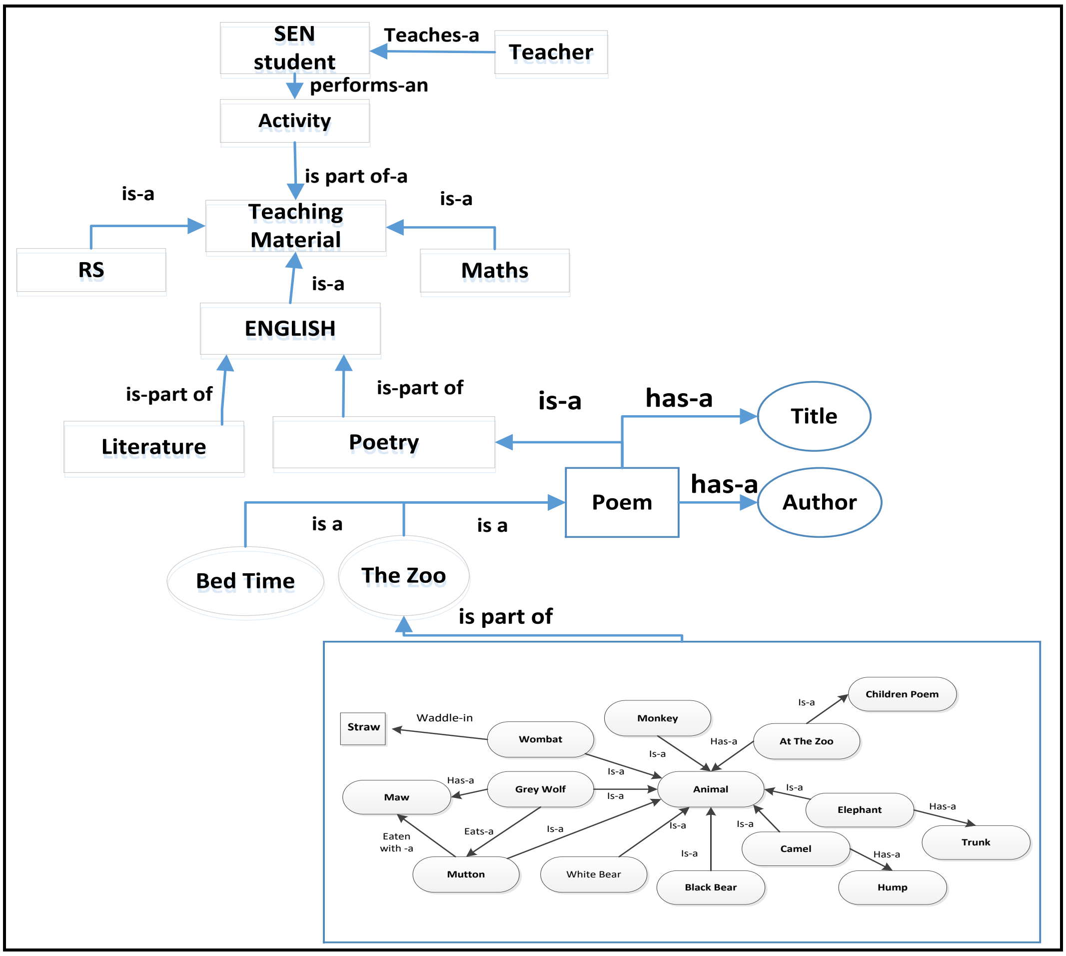

Figure 6.17: Extract of the SENTP Annotation Model for Poetry

The SENTP ontology is implemented using Protégé 5 as illustrated in Figure 6.18 and 6.19 below. Protégé is an open source freely obtainable ontology editor and knowledge base framework essentially an ontology visual editor, with a development framework that provides the crucial manipulations and query from ontology.

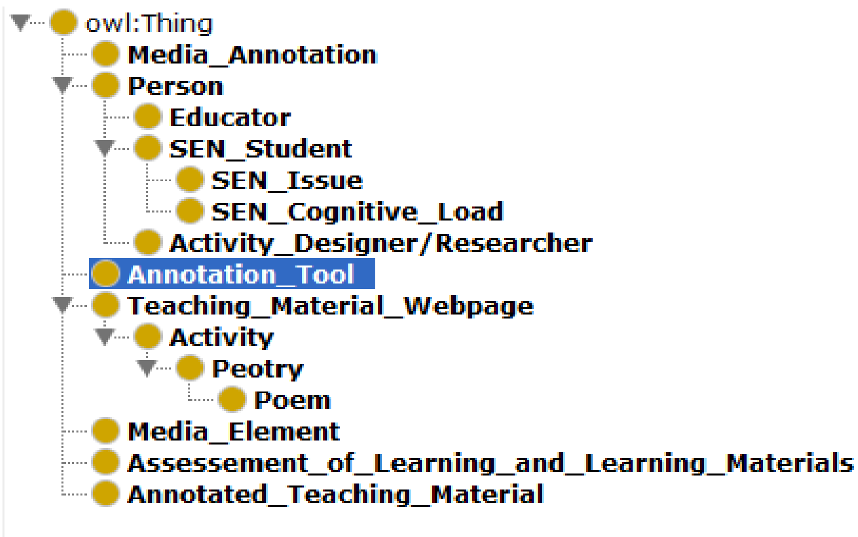

Figure 6.18: Screenshot of SENTP Ontology Identified in Protégé 5

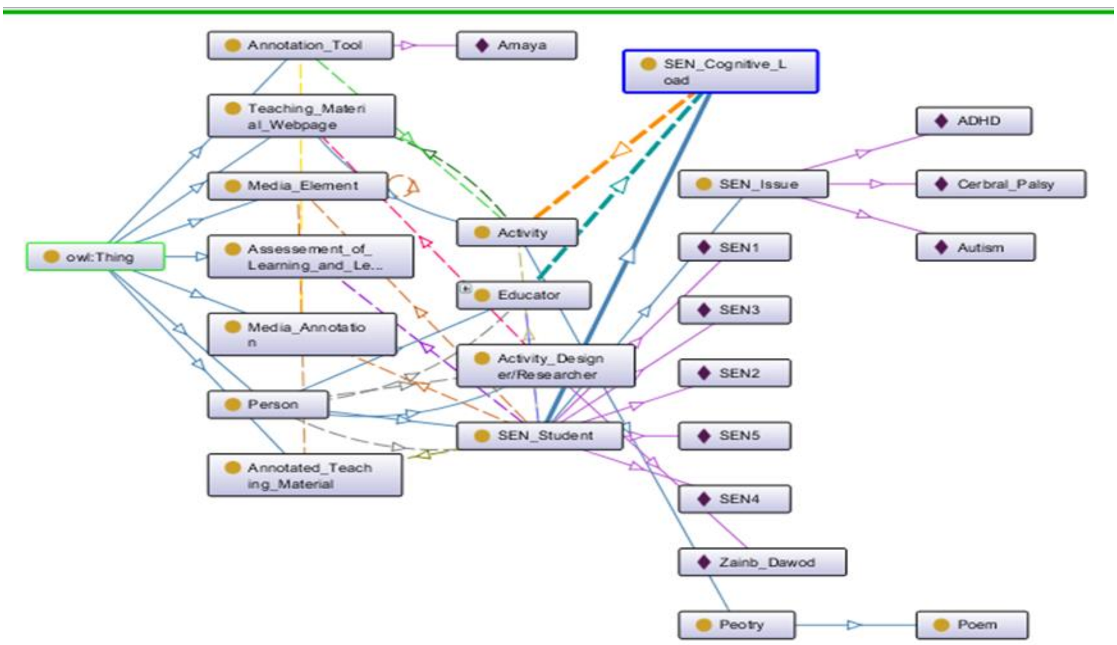

Figure 6.19: Sample of the SENTP OWL Ontology

(See Appendix G for more evidence)

6.12 Summary

As explained in chapter 2, 4, and 5, a considerable gap exists between Semantic Web utilisation in the field of mainstream education when compared to special educational needs education. The teaching methods available in a special needs school are typically based on time-consuming, manual methods. SEN can affect a child's ability to learn, their behaviour and ability to socialise. Reading, writing, understanding, concentration and physical abilities are also more limited (Chen, 2011). This chapter presents a novel approach to special needs teaching and learning and finds that Semantic Web annotation techniques can reduce the SEN cognitive load within the classroom. Consequently, the designs and resulting system (developed using Amaya) and the usage methodology enhances the learning process of SEN through the use of a range of annotation types.

Design practice underpinned all of this research. Design Science Research methods directed the constructs, models, methods and instantiations employed. The artefacts include both larger frameworks (e.g. SENTP) and smaller media content. Design contribution is then synthesized and generalized within a blueprint that details the pragmatics of deployments and, importantly, the interaction between stakeholders. Furthermore, SENTP ontology is designed and implemented for a wider design using Protégé 5.

Participant requirements defined the application of CLT principles within a number of technology artefacts. The platform was extended by following a set of methodological guidelines to reduce the SEN cognitive load, reducing the split-attention and redundancy effects. Interviews were conducted to identify the impacts of semantic annotation techniques when teaching poetry for students with wide range of SENs and with different levels of understanding. Interview analysis supported a combination of text with images, sound, or symbols in order to reduce the SEN cognitive load. Consequently, the classroom benefitted from reductions in behavioural problems and increasing SEN understanding. Poetry teaching material was used that supported CLT, increasing SEN engagement and motivation. The platform can also support teaching staff with class management techniques including resource preparation. Schools use different types of sign and symbol systems - many of which are integrated into the platform. Children with additional languages are also possible end users of the proposed approach.

There is a need to investigate further the use of different Semantic Web annotation techniques, such as semantic wiki, to build up as a flexible and reliable tool and library of usable content.

Chapter 7: Conclusions

7.1 Research summary

This chapter summarises the findings in response to the research questions and explains the main lessons learned from carrying out the research.

Semantic web technology has promised a number of benefits for a Web future in many fields, especially in education (Poland and Holohan, 2009). However, studies in this area have not considered the use of semantic annotation in preparing SEN teaching materials, taking advantage of current teaching methods such as the symbol systems (Makaton, PECS and Widgit), images and sign language symbols. Semantic web techniques have been applied in education to retrieve relevant content, and add semantic annotation to documents. However, special needs schools still heavily rely on manual methods such as the use of sign languages, photos, symbol systems and objects to help people develop their speech and vocabulary. There are three main symbol sets used by students in the UK: Widgit Rebus, Makaton and Picture Communication System (PECS). The communication systems used are computers, keyboards, voice simulators or materials like words, pictures, paper, boards, or symbol cards. Those students with SENs often have limited vocabulary, unlike other children of the same age, who typically have a dictionary-based vocabulary in their heads without the need to understand and memorise each word.

The use of semantic annotations plays a major role in the SEN Teaching Platform (SENTP) as it provides teaching staff with resources readily available. In comparisons with the current SEN interventions that are discussed in the literature review, adapting semantic annotation approach can have an effective impact on SEN learning and the process of teaching SEN students. SENTP saves the teaching staff time and effort and produces better learning results from the research findings in chapter 5 and 6. SENTP supports the teaching staff as they can select the required materials according to their student's age range and needs, and are able to share the material with other teaching staff. Normally, teachers use traditional methods to teach SEN students; they often have to utilise more than one resource when required. Manual methods within the classroom unsurprisingly require more staff to support SEN classes with varied abilities and needs.

This study investigated the applicability of using semantic annotation techniques to improve student learning and to support teaching staff. This thesis presents a novel approach to special needs teaching and learning and finds that Semantic Web annotation techniques can reduce the SEN students's cognitive load within the classroom. Consequently, the designs and resulting system and the usage methodology enhances the learning process of SEN using a range of annotation types. Design Science Research methods directed the contructs, models, methods and instantiations employed. The artefacts included creating new language for annotation, SENTP model, annotation method and SENTP prototype. The findings from these artefacts were then synthesised and generalised within a blueprint that details the pragmatics of deployments and importantly the interaction between stakeholders. Moreover, SENTP ontology is developed for a generalised concept of SEN learning resources to share the annotated teaching content between the stakeholders.

The SDM framework needs to evolve to build SENTP artefacts to make use of semantic annotation in teaching SEN students a practical reality. Consequently, this thesis has aimed to assist researchers in building and maintaining a low-cost tool that requires less time and effort from the teaching staff to prepare their resources for each lesson. This aim was achieved by developing a SDM framework, building a SENTP application, building and developing SENTP ontology, synthesising a SENTP application and designing a blueprint. The objectives as set out in chapter 1 are summarised below:

1. Review the available SEN teaching resources to provide an understanding of the state-of-art of special needs learning resources and to identify the limitations of the current teaching methods.

2. To conduct a comprehensive literature review in a Semantic Web innovation with a focus on adapting semantic annotation in education with the aim of identifying the associated gaps in using semantic annotation in teaching SEN students.

3. To develop an ontology seeking to identify the main design constructs along with their semantics and relationships that are needed to be examined with SEN teaching material.

4. To develop a conceptual framework of the SEN learning model concept that identifies and links between the main components of the concept (semantic annotation) along with its modelling principles, practical functions within schools for SEN students, and its relationships with other relevant concepts such as the learning methods and styles, issues and the teaching staff requirements

5. To develop and implement a tool that facilitates the framework by employing semantic annotation techniques in SEN learning materials

6. To evaluate and demonstrate the practical adequacy of utilising semantic annotation techniques in SEN students' education using suitable evaluation methods.

7.
8. To design a Blueprint to synthesise policy recommendations describing the interaction between students and activity designer to generalise the process of creating media element within SEN environment.

9. To draw conclusions from the building and evaluating the use of semantic annotation in developing special needs resources to enhance SEN learning. Also, identify future research directions that are important to continue refining and developing this significant area of research.

In achieving the aim and objectives of the work, **chapter 2** reviewed four intersecting fields of research relevant to this study. Firstly, different types of special needs issues and their associated styles of learning were discussed to identify the technical requirements in SENTP design. Secondly, different types of teaching resources were reviewed to identify the limitations of the current methods and the user requirements. Thirdly, the use of ICT in teaching SEN students was described to show its applicability in teaching this group of students. Finally, chapter 2 presented various semantic web techniques, including semantic annotation tools, and focused on two tools selected to be used in this research. In the context of this research, the literature provided evidence that all the existing resources should include visuals to support classes that have different types of SEN issues and a wide range of mental ages. Furthermore, all the limitations of learning needs which depend on their learning styles were identified. Moreover, it shows that using ICT in preparing special needs resources can be an effective tool to develop student's learning. Additionally, there are many studies that have discussed semantic web employment in education, and there have been a few studies focused on employing semantic annotation techniques in teaching. Nevertheless, there is no evidence that semantic annotation tools employing the existing forms of SEN resources (images, symbol systems, sound or video) are used in teaching special needs. Consequently, an opportunity for furthering knowledge lies in introducing semantic annotation techniques using different forms to improve student learning and to support teaching staff.

Chapter 3 sets out the means for achieving the objectives via Design Science Research. DSR approach provides means by which to engage in the design problem by providing the necessary learning to improve the proposed solution. In addition, enriches the solution space with the Design Science Research outputs. The main Design Science Research artefact is a SEN Development Media methodological framework (SDM). The overall research methodology is executed as Design Science Research incremental iterations, where each of the three iterations forms a design problem that executes the build and evaluate design activities (March and Smith, 1995; Vaishnavi and Kuechler, 2004).

The iterations were designed such that Iteration one developed a new way of describing the language such as Bigger (font), Smaller (font), Video, and Image. In iteration one an initial framework SDM was designed. Furthermore, the process of using semantic annotation in teaching special needs was tested. Also, two instantiations were built, implemented and compared, which resulted in building a school a model. Iteration two extends the framework by adding further annotation forms to describe the language such as Makaton, PECS, Widgit, and Sound. The changes in the design of the SENTP model resulted in extension of the SENTP Instantiation, which was tested using qualitative methods in a pilot study. The framework in Iteration 3 is extended by considering CLT in SENTP user interface design. The semantic annotation process using the CLT is introduced in this iteration and tested in field testing using qualitative methods within different SEN domains. Additionally, a SENTP blueprint and ontology model synthesised policy recommendations to generalise the concept of this research.

The products of the Design Science Research included constructs, methods, models and instantiation in order to facilitate the framework development. Design Science Research activities were applied in incremental iterations to build and effectively evaluate each of the design research products as illustrated in Table 7-1. Design Science Research products were evaluated using evaluation criteria. The evaluation column demonstrates the successful application of each product in the final SENTP tool.

	Build	Theorize	Evaluate
Construct	New way of describing a language such as symbol systems (Makaton, Widgit, PECS or signalong), image, sound or combination of two media.	Explained why and how constructs work by employing the annotation to describe different teaching materials. (Addressed in chapters 2, 4, 5 and 6)	Literature review used to define a new way to describe language for SEN. (Addressed in chapters 2, 4, 5 and 6)
Model	SENTP ontology SENTP framework	Adapted theories related to the current SEN education discipline and the use of semantic annotation in education, and employed them in a real SEN environment. (Achieved in chapters 4, 5 and 6)	SENTP model used constructs to describe a real-world SEN situation of the design problem. SENTP ontology model used to express relationships between constructs. Also, SENTP
Method	Process of semantic annotation Ontological approach-constructing SENTP ontology Adapting CLT in the design of SENTP webpage SENTP Methodology SENTP blueprint.	Explained why and how methods are applied using a real SEN class environment Explained the use of Design Science Research methodology to develop SENTP over three iterations. (Achieved in chapters 4, 5 and 6)	All the steps followed to achieve the solution space are identified. Full process to solve the problem using the constructs and the models is presented. (Demonstrated in chapters 5 and 6) blueprint method is presented. (Addressed in chapters 2, 4, 5 and 6)
Instantiation	Web tool SENTP Webpage	Demonstrated how and why application works within SEN learning domain for different subjects, SEN issues and SEN age range. (Achieved in chapters 5 and 6)	The implementation of constructs, models and methods within a working system is demonstrated. The researcher learned about the working artefact in a real scenario. (Achieved in chapters 5and 6)

Table 7.1: Design Science Research SENTP Artefacts

Chapter 4 described the approach for building a school model. Different types of semantic annotation techniques and semantic annotation tools were reviewed to select the suitable one to build the SEN school system. Different versions of Protégé were tested such as Protégé (3.4- 4.1- 4.2). OWL2 with Protégé 4.1 was selected to implement the SEN ontology. Furthermore, different annotation tools such as Amaya, OntoMat and Magpie, were tested for their applicability in this research. This selection was based on the annotation process, such as manual, semi-automatic and automatic in each tool. Two semantic annotation tools were selected (Amaya and OntoMat) to build prototypes for comparison. Different ontology based applications were tested such as RDF and OWL2 to build the SEN ontology and OWL was used to build the SEN ontology. Moreover, HTML is used in chapter 4 to build an educational, poetry website. This choice was based on the website code that is accepted by the annotation tools selected for the purpose of this study. By the end of chapter 4, the focus of the tools selection is on testing the applicability of semantic annotation in SEN domain. Special need domain is a sensitive domain because of the common indicators of teaching special need students which require a user-friendly application. Amaya was selected as an appropriate tool to build the school application. The selection of Amaya was based on the evaluation criteria (Section 4.2.2 and the literature review in chapter 2).

Chapter 4 tested the applicability of utilising semantic annotations in designing special needs learning materials. This evaluation highlighted the need for using practical methods in testing the SENTP in a real SEN domain. If the SENTP is developed for such a sensitive domain, the robustness of the application should be tested in adverse operating school conditions. This initiated another DSR step, evaluation of the SENTP by piloting in schools catering for SEN students, which is described in the following chapter.

Chapter 5 extends SENTP by adding the symbol systems such as Makaton, PECS and Widgit which are part of the existing methods used to teach SEN students. Hence, in this chapter the SDM framework was extended and a SENTP application was developed and tested in a real-world environment. In addition, this chapter described the pilot study with all the data collected from two types of schools in the UK. Nine interviews were conducted with the teaching staff to benefit from their wider experiences. All the data collected was analysed with Nvivo 10.

The contributions in this chapter included, firstly, a construct which is a new way to describe the language (adding the symbol systems concept). Secondly, the chapter described a method of using a semantic annotation process with the constructs (method) was described. Thirdly, the method was adopted in the design of the SENTP model. Finally, the model was employed to implement a SENTP tool (instantiation) for the pilot study. It was shown in the pilot study that Amaya annotation tool enhanced the learning process of the special need students and it can be applied to other subjects. The learning process includes better understanding, reduced behaviour problems, increased engagement and concentration in addition to saving the staff time and effort in preparing the learning materials. Moreover, it proved that semantic annotation tools can be an effective way to teach students English as a second language. Finally, to generalise the concept of the study and to prove the findings from previous chapter, further analysis, investigation and a wide range of data sets was required. Generalising the concept required evidence of the tool applicability for diverse special needs issues, mental age groups, learning materials and types of school.

Chapter 6 addressed all the research objectives by demonstrating the utility and practical adequacy of the SENTP model, creating a SENTP blueprint and ontology for wider design. The chapter presented first a refined version of the SDM framework by adding cognitive strategies to help the students learn efficiently. Thereafter, the chapter detailed the adaptation of the CLT in the design of the SENTP user interface to reduce the students' cognitive load (method). The CLT theory has largely been defined by Mayer's cognitive theory of multimedia learning. According to the theory, the media element is presented by building mental representations from words and pictures, symbol and text or sound and pictures. The SENTP tool is extended by considering CL effects in the design of the SENTP Instantiation to reduce the students' cognitive load. The CL effects that were considered were split attention effect, redundancy effect and modality effect which were explained in chapter 6 (Section 6.4). Also, chapter 6 described the evaluation of the proposed annotation approach by testing the SENTP in a real-world domain.

To test the SENTP, its performance was evaluated in field testing by six schools for SEN students in the UK. A deeper understanding of how and why the SENTP works was achieved from interviewing twenty-two teaching staff from diverse school sectors. The conducted evaluation showed that the proposed approach is effective since the students' engagement and concentration were increased and their behavioural problems were reduced. In addition, the SENTP supported the staff by reducing the time and effort in preparing their learning resources as well as reducing the demands on the existing manual methods. Moreover, that annotated SEN teaching materials improve learning for autistic children is confirmed by five study participants. Furthermore, younger students, who's English is a second language, also benefited from the SENTP approach. Finally, the designed artefacts were synthesised within a wider design blueprint that showed how media content can be designed to be applicable for SEN requirements, deployed and consumed. It demonstrated the interactions between the students and the designer or the teacher by the underpinning of semantic annotation techniques. Additionally, a SENTP ontology model was developed, using Protégé 5, from the previous ontology which was initially developed in chapter 4 using OWL and protégé 4.2. The ontology was presented for a wider SEN design model which demonstrated the model for using semantic annotation to annotate learning content. The ontology elements were represented as classes and subclasses and relationships, data properties and object properties using OWL and protégé 5. The ontology was aimed for diverse special need issues, mental age group sets, school sectors and learning content.

Before the discussion of the most important contributions to theory, practice, and methodology, Table 7.2 outlines the objectives of the research, and the chapters covered and how they were achieved.

Objective	Chapter	Accomplishments
O.1- Review the available SEN teaching resources to provide an understanding of the state-of-art of special needs learning resources and to identify the limitations of the current teaching methods.	Chapter 2, 5 and 6	This objective was achieved in chapter 2 through expert interviews covering the following related fields: Current Teaching Methods, Special needs issues, their learning styles, the use of ICT in teaching special needs, and their concerns.
O.2- To conduct a comprehensive literature review in a Semantic Web innovation with a focus on adapting semantic annotation in education with the aim of identifying the associated gaps in using semantic annotation in teaching SEN students.	Chapter 2 and 4	This objective was achieved in chapter 2 although chapter 4 discussed and developed the semantic annotation techniques to compare and select one tool for testing in a real-world.
O.3- To develop an ontology seeking to identify the main design constructs along with their semantics and relationships that are needed to be examined with SEN teaching material.	Chapter 4 and 6	Discussed the developed ontology along with its design constructs in addition to their relationships and semantics in the context of SEN learning.
O.4- To develop a conceptual framework of the SEN learning model concept that identifies and links between the main components of the concept (semantic annotation) along with its modelling principles, practical functions within schools for SEN students, and its relationships with other relevant concepts such as the learning methods and styles, issues and the teaching staff requirements.	Chapter 4, 5 and 6	We accomplished the fourth objective in chapter 3 and described it in detail in chapter 4, 5 and 6 as a SDM framework of the special need learning model concept is provided. In chapter 3, the main dimension of the SENTP was identified. The modelling principles and features, and its intersection between strategy concept, CLT and the semantic annotation in teaching special needs are identified in chapter 6.

Objective	Chapter	Accomplishments
O.5- To develop and implement a tool that facilitates the framework by employing semantic annotation techniques in SEN learning materials.	Chapter 5 and 6	The SENTP was built, implemented, tested and compared in chapter 4 to prove the applicability of using semantic annotation in teaching SEN students and selected a tool for the pilot study. In addition, the principles of CLT were adopted in the design of the SENTP user interface to achieve better student understanding. The SENTP is tested in a real-world in chapter 5 and 6 by using staff experiences within different SEN domains.
O.6- To evaluate and demonstrate the practical adequacy of utilising semantic annotation techniques in SEN students' education using suitable evaluation methods.	Chapter 4, 5, and 6	The SENTP is evaluated in a real SEN environment at eight educational institutions caring for students with various SEN issues and age ranges. The evaluation resulted in adding new audiences who can benefit from using the concept of utilising semantic annotation in the SEN teaching material such as students with English as a second language. Also, the evaluation showed significant support for autistic students, students with language and communication difficulties and ADHD students.
O.7- To design a Blueprint to synthesise policy recommendations describing the interaction between students and activity designer to generalise the process of creating media element within SEN environment.	Chapter 6	The SENTP Blueprint was designed in chapter 6 to present the process of designing a media element for special needs student and the interaction between the students and designer/teaching staff.
Q8- To draw conclusions from the building and evaluating the use of semantic annotation in developing special needs resources to enhance SEN learning. Also, identify future research directions that are important to continue refining and developing this significant area of research.	Chapter 7	The objective was achieved in this chapter (chapter 7).

Table 7.2: Accomplishment of the Research Objectives

7.2 Research Contributions

Research contributions are categorized according to the Design Science Research product classification. Contributions in a DSR study are in forms of artefacts (constructs, methods, models, and instantiations) (March, Smith, 1995; Vaishnavi and Kuechler, 2004; Hevner et al. 2004). The artefacts derived from this research are summarised below:

New way to describe the language (construct)

Although, annotations were used widely in the academic literature as described in chapter 2 (Table, 2.4, Section 2.5.4), they had not been applied to special educational needs material as illustrated in chapter 2 (Table 2.5). For example, Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas (2017) discussed the use of video tools in teacher training and reviewd all the relevant studies. These studies included research articles and conference proceeedings. The review covered all the authors studying how video annotation improves teaching and suggested a significant potential in teaching. Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas (2017) suggested that studies on video annotation in teacher training are new in this area. Additionally, studies have not found a link between reflective teaching and the use of these tools in children education. Consequently, using different forms of annotation (pictures, symbols (Makaton, PECS, Widgit or sign language symbols), text, sound or video) are new in the area of SEN teaching (Pérez-Torregrosa, Díaz-Martín and Ibáñez-Cubillas, 2017). Hence, this construct is unique when compared with the existing state of art such as Andrews, Zaihrayeu, and Pane (2011).

A new way to describe the language is a novel generic construct that is added to the SENTP UI to facilitate the learning of special needs. The forms of annotations were demonstrated as pictures, symbols (Makaton, PECS, Widgit or sign language symbols), text, sound or video. The construct was tested using the new semantic annotation in iteration one (chapter 4) by adopting semantic annotation in two platforms (Amaya and OntoMat Annotizer) to compare their applicability within a SEN domain. In iteration two (chapter 5), the construct is extended by the addition of the symbolic systems. In iteration three (chapter 6), the annotations were demonstrated according to CLT. These forms of annotations were tested for their efficiency in chapter 5 and 6 from interviewing 31 experts at 8 educational institutions.

The SDM methodological framework (method)

The main contribution made by this research is a generic framework method that enables application of the SENTP in different SEN domains. This method assessed the effectiveness of utilising semantic annotation to enhance SEN teaching. The methodological framework (chapter 4, 5 and 6) was used to develop the application in a set of steps to enhance SEN students understanding of teaching content. Firstly, semantic annotations were employed to test the construct through the design of educational webpages annotated with new forms of annotations to describe the language. The initial annotation forms were represented as 'Bigger' (bigger font), 'Smaller' (small font), 'Sound', 'Images', 'Image and Information', 'Video', and 'Information'. The initial prototype was tested in an experiment to evaluate the suitability of using semantic annotation in the design of special need's resources (testing construct). The effectiveness of the initial SDM framework was discussed in detail in chapter 4 (Section 4.6 and Table 4.7). Secondly, a new form of annotation was added utilising one of the most popular current concepts of the learning materials (symbol systems) (Abott and Lucey, 2005). The platform was evaluated with a qualitative method (9 interviews of teaching staff) in a pilot study (chapter 5). The effectiveness of this framework was discussed in detail in chapter 5 (Section 5.7 and Table 5.7). Thirdly, CLT was adopted to redesign the annotation forms in the educational webpage learning material to reduce student cognitive load. This step was evaluated with qualitative methods (22 interviews of teaching staff) in field testing (chapter 6). The effectiveness of this framework was discussed in detail in chapter 6 (Section 6.7 and Table 6.6).

The framework provides a novel way to gradually construct SEN learning annotation content based on current concepts of SEN learning materials requirements. In addition, all the artefacts were evaluated for their efficiency by experts in a real environment (Prat, Comyn-Wattiau, and Akoka, 2014). The results of the field testing demonstrate that proposed the framework is applicable for diverse age ranges, SEN issues and students learning styles. Although, many studies have investigated frameworks for semantic annotations in teaching, as explained in chapter 2 (literature review), there is no evidence of a framework for SEN students having been designed.

Currently, children with special needs learn using symbol cards, prepared images or other applications purchased by the school as described in Literature review (Section 2.3). For example, Uren et al. (2005) investigated the use of semantic annotation in knowledge management. Whereas, Malik et al. (2010) investigated a semantic annotation framework for intelligent information retrieval. Despite the considerable efforts having been made in designing educational frameworks, these previous frameworks are not based on the use of semantic study and the use of semantic annotation in teaching special need students. Hence, the development process of the SDM framework is a contribution to DSR.

SENTP ontology (Model)

Another important contribution is the ontological model in chapter 6. In chapter 4 it was shown that an ontology based approach is an effective approach which can offer an opportunity to wide metadata sharing (see Section 4.4.3 and 4.4.5). This was then generalised in chapter 6 as OWL ontology (Section 6.9, Figure 6.16). The ontology in chapter 6 contributed with a novel general ontological model. The SENTP ontological model benefited from CLT to describe and find annotated learning content with annotation forms for special need issues with a specific learning style or within specific age ranges. The learning content that is appropriate for individual needs is selected by educators or students.

The SEN ontology model was developed using OWL2 with Protégé 4.2 (chapter 4) and Protégé 5 (chapter 6). The SENTP ontology in chapter 4 was designed for learning poetry by creating classes, a datatype objects and relationships between the classes. The model is extended in chapter 6 by adding classes, instances, and object properties which are related to special needs students' different issues such as autistic, communication difficulties or Asperger syndrome, and the effects of cognitive load on learning any educational content.

There are some studies which have investigated building models with semantic annotation to support the teaching process as explained in chapter 2. For example, Azouaou and Desmoulins (2005) propose a model of using semantic annotation that is dedicated to the teacher's specific activities. The teachers in this model should annotate the physical and logical structure of the document itself. The lack of explicit annotation semantics makes it difficult to reuse the annotations. However, this model did not consider special need student requirements. Azouaou and Desmoulins subsequently proposed a conceptual model of a language based on ontologies. They used these ontologies to propose an annotation model (MemoNote) to enable teacher annotation. Another model, proposed by Alpert et al. (1999), acts as a personal tutor for keeping track of students' progress over time. However, there is no evidence of a designed model which uses semantic annotation and cognitive load theory to support the special needs learning or any designed ontology for enhancing special educational needs learning.

SENTP Blueprint (method)

The thesis presented a generalised novel Blueprint method for special needs learning. The blueprint method was synthesised from the outcomes of the three iterations (chapter 4, 5, and 6).

The SENTP blueprint method described the process to produce a generalised concept of using different forms of semantic annotations for enhancing special educational needs learning. The blueprint showed all the strategies followed from planning to analyses and demonstration of physical evidences. It presented the student interactions with the designer/educator to show all the activities at the 'front-of-stage' and 'back-of stage' lines to prepare effective learning material. The blueprint showed all the support processes that are within internal interaction.

Prototype (A set of Instantiations)

All the above contributions were tested in instantiations at different stages of the research in different SEN domains. Two platforms were designed and implemented in chapter 4 for comparisons, then the selected school platform was extended in chapter 5 and the instantiation was evaluated in pilot study. Another extension for the instantiation was conducted in chapter 6 and evaluated in field testing.

7.3 Research Limitations and Future Work

Although the research has made a number of valuable contributions to the SEN teaching domain, a number of limitations and challenges may be noted:

- Firstly, although the data were collected from various types of schools with a sufficient sample size interviewed, all the participants are teachers, teaching assistants and headteachers. More in-depth feedback could be collected from other people who are in contact with SEN students frequently, such as language therapists and carers. In addition, data could be collected from special needs students who can give a deeper understanding of the benefits and challenges.
- The SENTP was demonstrated to children in the age range 2.5–19 years. The physical age of some of the SEN students is considerably different from their mental age. For example, in a class age range 7-9, there are students that are mentally a couple of months old. Thus, the SENTP should consider the SEN students' mental ages by adapting it to a younger age. For instance, a teacher from the special high school who teaches students with very severe learning disabilities reported that her class has students in the age range 11–19 years old, but their mental abilities were a few months old.

The list of limitations and associated improvements discussed earlier are not intended to diminish the contributions of this thesis. Instead, they propose great opportunities for further investigations.

There is scope for this research to be progressed further to form an SENTP that can benefit a larger number of people. During the development phase, the following areas for further work were identified:

1. The SENTP can be extended to suit a wide age range, issues and styles by adapting the developed ontology in chapter 6 and testing it with another annotation tool.
2. One of the important directions for future work is building SEN Wiki to provide an easy to use resource which can be available any time. The SEN Wiki allows educators to add any content and to share teaching content between stakeholders.
3. The SENTP can be extended to be used with iPads, as reported by a teacher from the special high school. The educator suggested the ipad tablet to encourage the students to work independently, anytime or in anyplace.

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APPENDICES

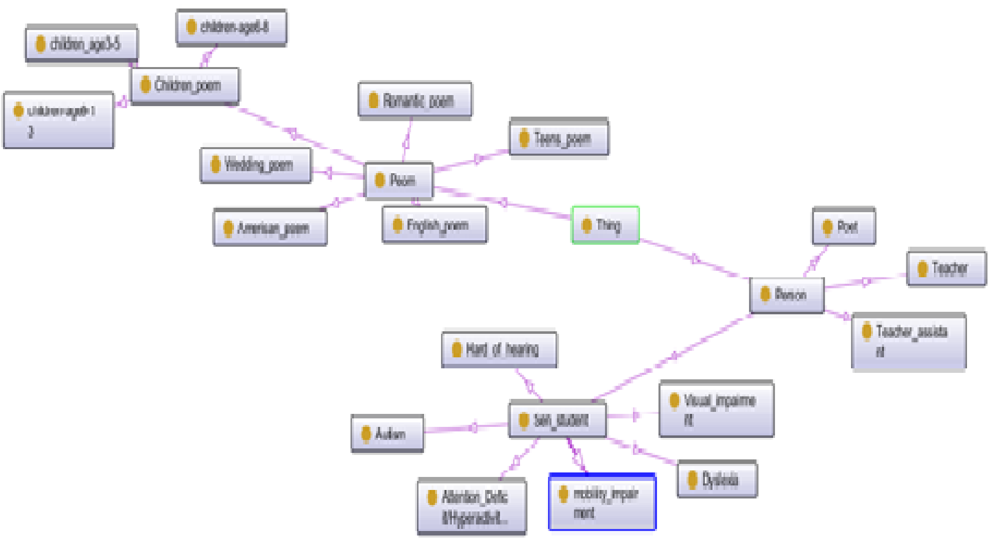
Appendix A – Annotation Experiment (Iteration One)

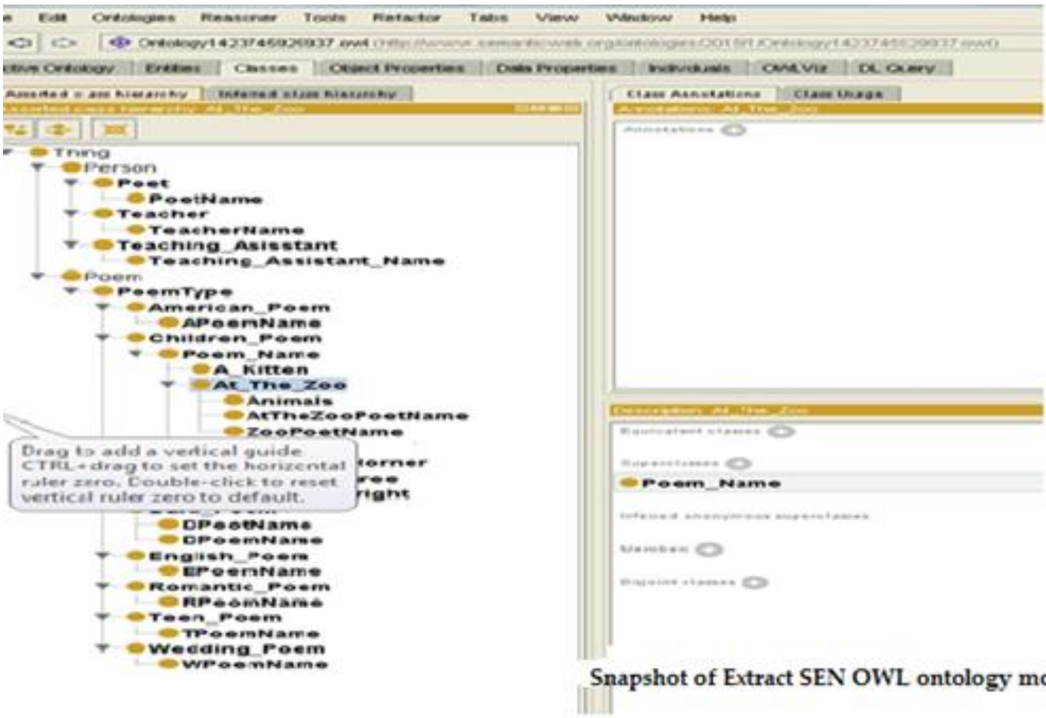
1-SEN Ontology Code


```
<!-- http://www.semanticweb.org/ontologies/2015/1/Ontology1423745929937.owl#Black_Bear -->

<owl:DatatypeProperty rdf:about="#Black_Bear"/>


<!-- http://www.semanticweb.org/ontologies/2015/1/Ontology1423745929937.owl#Camel -->

<owl:DatatypeProperty rdf:about="#Camel"/>


<!-- http://www.semanticweb.org/ontologies/2015/1/Ontology1423745929937.owl#Elephant -->

<owl:DatatypeProperty rdf:about="#Elephant"/>


<!-- http://www.semanticweb.org/ontologies/2015/1/Ontology1423745929937.owl#Grey_Wolf -->

<owl:DatatypeProperty rdf:about="#Grey_Wolf"/>


<!-- http://www.semanticweb.org/ontologies/2015/1/Ontology1423745929937.owl#Monkey -->

<owl:DatatypeProperty rdf:about="#Monkey"/>


<!-- http://www.semanticweb.org/ontologies/2015/1/Ontology1423745929937.owl#Mutton -->

<owl:DatatypeProperty rdf:about="#Mutton"/>
```

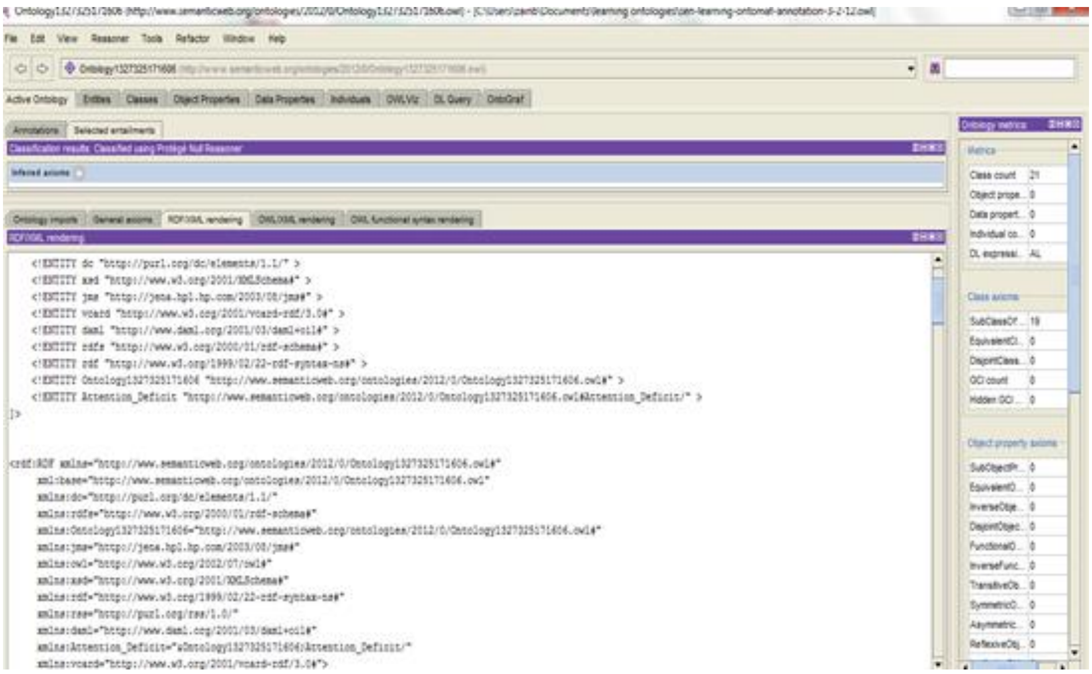
Part of STP ontology code with Protégé 4.2

SEN Ontology graph



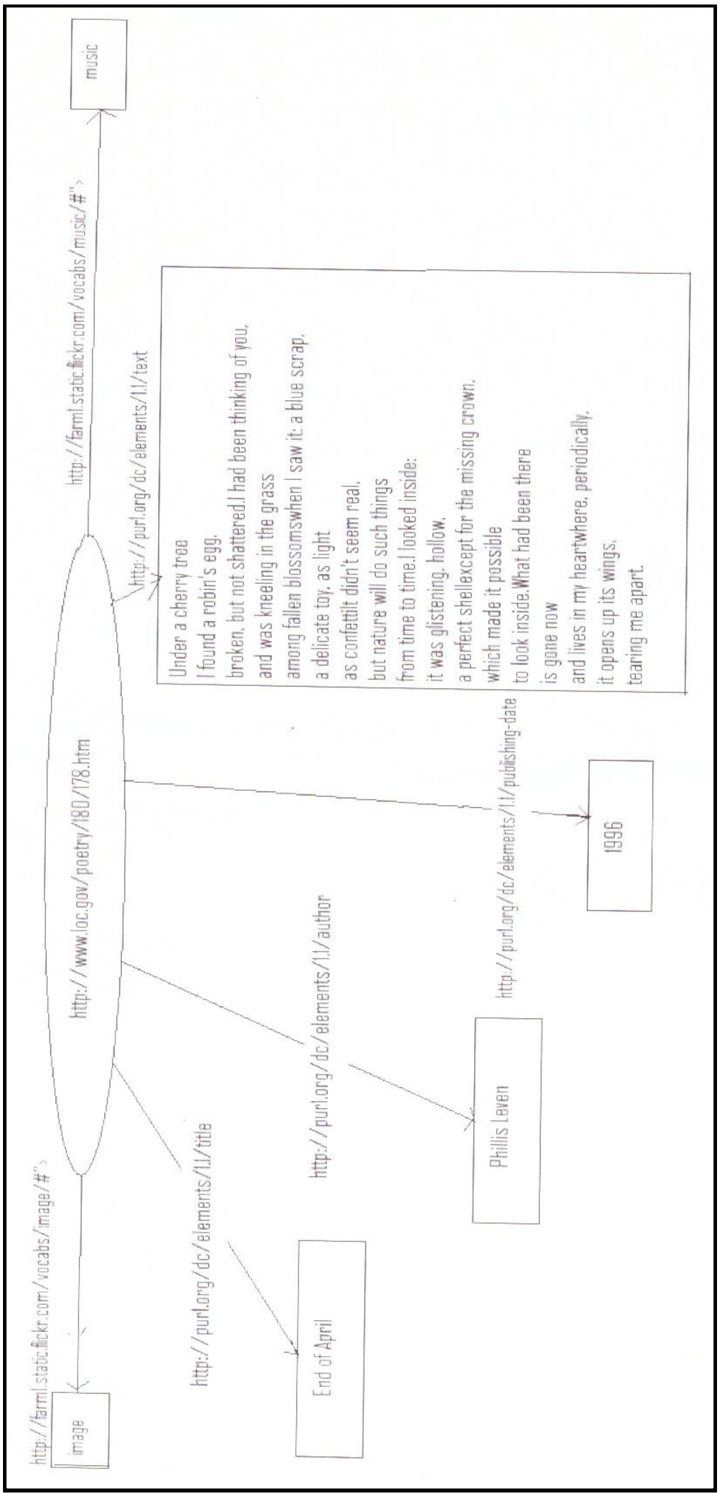


Snapshot of Extract SEN OWL ontology model



-Valid Based Language using RDF Validator

- RDF Graph



RDF VALIDATIOR

```
<?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:s="http://example.org/studentwithsen/vocab#"
    xmlns:dc="http://purl.org/dc/elements/1.1/">

  <rdf:Description rdf:about="http://example.org/poem/6.001">
  <s:studentwithsen>
  <rdf:Bag>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Defreitas P"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Croll P"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Caballe M"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Harrison L"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Robinson M"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Loughran L"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Finding G"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Ali S"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Mohamad N"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Hassan F"/>
  <rdf:li rdf:resource="http://example.org/studentwithsen/Hussain H"/>
  </rdf:Bag>
  </s:studentwithsen>
  </rdf:Description>

    <rdf:Description rdf:about="http://www.loc.gov/poetry/180/178.html">
      <dc:title>End of April</dc:title>
    </rdf:Description>
    <rdf:Description rdf:about="http://www.loc.gov/poetry/180/178.html">
      <dc:author>Phillis Leven</dc:author>
    </rdf:Description>
    <rdf:Description rdf:about="http://www.loc.gov/poetry/180/178.html">
      <dc:publishing-date>1996</dc:publishing-date>
    </rdf:Description>
    <rdf:Description rdf:about="http://www.loc.gov/poetry/180/178.html">
      <dc:text>Under a cherry tree
  I found a robin's egg,
  broken, but not shattered.

  I had been thinking of you,
  and was kneeling in the grass
  among fallen blossoms

  when I saw it: a blue scrap,
  a delicate toy, as light
  as confetti

  It didn't seem real,
  but nature will do such things
  from time to time.

  I looked inside:
```

image Annotator


```xml
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:dc="http://purl.org/dc/elements/1.1/"
 xmlns:image="http://farm1.static.flickr.com/vocabs/image/#">
 <rdf:Description rdf:about="http://www.loc.gov/poetry/180/178.html">

<dc:image>"http://farm1.static.flickr.com/23/31308974_04f82da89c.jpg"</dc:image>
 </rdf:Description>
</rdf:RDF>
```


Poem has image

Poem has music


```xml
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:dc="http://purl.org/dc/elements/1.1/"
 xmlns:image="http://farm1.static.flickr.com/vocabs/music/#">
 <rdf:Description rdf:about="http://www.loc.gov/poetry/180/178.html">
  <dc:music>"http://www.youtube.com/watch?v=P8BgKzdd9Mg"</dc:music>
 </rdf:Description>
</rdf:RDF>
```

```
it was glistening, hollow,
a perfect shell

except for the missing crown,
which made it possible
to look inside.

What had been there
is gone now
and lives in my heart

where, periodically,
it opens up its wings,
tearing me apart.

</dc:text>
  </rdf:Description>
</rdf:RDF>

<rdf:RDF
```

Image Annotator

```
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:dc="http://purl.org/dc/elements/1.1/"
xmlns:foaf="http://xmlns.com/foaf/0.1/"
xmlns:image="http://jibbering.com/vocabs/image/#"
xmlns:an="http://www.w3.org/2000/10/annotation-ns#"
>
 <foaf:Image
rdf:about="http://farm1.static.flickr.com/23/31308974_04f82da89c.jpg">
  <image:hasPart>
   <image:Rectangle rdf:ID="p1">
    <image:points>1,2 434,495</image:points>
    <dc:title>End of April</dc:title>
    <dc:description>Under a cherry tree
I found a robin's egg,
broken, but not shattered.

I had been thinking of you,
and was kneeling in the grass
```

Appendix B- Research Interviews Agenda (Iterations Two andThree)

- Statement of Ethics Approval

School of Information Systems, Computing and Mathematics
David Gilbert, Head of School, Professor of Computing
Jasna Kuljis, Head of Information Systems and Computing, Professor of Computing
Tony Rawlins, Head of Mathematical Science, Professor of Mathematics

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Date: 09 December 2011

STATEMENT OF ETHICS APPROVAL

Proposer: ZAINB DAWOD

Title: Enhancing Special Educational Needs Learning with Semantic Web Tools

The school's research ethics committee has considered the proposal recently submitted by you. Acting under delegated authority, the committee is satisfied that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that you will adhere to the terms agreed with participants and to inform the committee of any change of plans in relations to the information provided in the application form.

Yours sincerely,

Zidong Wang

Professor Zidong Wang
Chair of the Research Ethics Committee
SISCM

- Consent form

Brunel UNIVERSITY LONDON

CONSENT FORM

<u>The participant should complete the whole of this sheet him/herself</u>

Please tick the appropriate box

		YES	NO
1.	I confirm that I have read and understand the information sheet.	☐	☐
2.	I agree to participate in the study.	☐	☐
3.	I understand that taking part in the study is voluntary and I am free to withdraw at any time.	☐	☐
4.	I agree to the interview being audio recorded.	☐	☐
5.	I agree to the use of non-attributed direct quotes when the study is written up or published.	☐	☐
6.	I agree that my data collected in this study will kept confidential.	☐	☐
7.	I have had the opportunity to ask questions and discuss this study.	☐	☐
8.	I understand that I will not be referred to by name in any report concerning the study.	☐	☐
9.	I give permission for the researcher to store the information given in the interview for the duration of the study and understand that it will then be stored at Brunel University for the archiving period (Up to ten years).	☐	☐

____

Name of Participant: Signature: Date:

____

Name of researcher: Signature: Date:

-Information Sheet

Brunel University

INFORMATION SHEET – main study

Study Title: Designing Semantic Web Educational Tools to Enhance the Learning of Special Educational Needs Students with the use of Cognitive Load Theory.

You are being invited to take part in my research study. Before you decided whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following carefully.

What is the purpose of the study?
I decided to improve Special Educational Needs (SEN) learning methods and for the purpose of my research I chose teaching Poems. I will use semantic web tools to develop the learning methods for teaching SEN poems. I plan to explore the experiences that teachers and teaching assistant have had of working with the traditional way of teaching poems and how semantic web tools can make a difference. I will look at the factors affected by using semantic web tools. All the participants will be adult.

Aims
To improve Special Educational Needs (SEN) web educational materials with more supportive learning methods using Semantic Web Tools.

Why have I been invited to participate?
As a primary/secondary teacher or teaching assistant you have valuable experience of working with children with the range of age required for my research purposes. Also, as SEN teacher or teaching assistant you can provide effective feedback about the testing materials in addition to your valuable experience with different graphic symbols. Your name will not be identified but your headteacher has agreed to pass this information sheet on my behalf as you meet the criteria of the research.

Do I have to take part?
Taking part in the research is entirely voluntary. If you do decide to participate you will be given this information sheet and be asked to sign a consent form. If you decided to take part you are free to withdraw at any time and without given a reason.

What will happen to me if I participate?
You will be involved in face to face interviews at a time that is convenient to you and your headteacher. All the interviews need to be recorded. The interview questions are all about your experience and views. The first set of the questions are about your current experience and methods used to teach SEN students and the other set is about the use of semantic web tools in teaching SEN and especially teaching poems with group of SEN students of ages between 3-6, another group between 7-9 and the third group between 10-13. Before the interview you will be asked to sign a consent form to confirm your agreement to attend the interview.

Are there any potential risks?
There are no risks or harm in taking part in this research. All participants will have the right to refuse to answer any questions they are not happy with.

What happens to the information collected?
I will be the only person with access to your information but my supervisors may access the recording for monitoring purposes. No personal details or information from which you may be identified will be included in my research. The consent form and the tape recording of the interview will be kept securely.

Please get in touch if you would like further information:
Researcher: Zainb Dawod – Tel 07984604175; email: Zainb.Dawod@brunel.ac.uk
Research supervisor: Dr David Bell; David.Bell@brunel.ac.uk

-The letter sent to Participants-Pilot study

Dear Sir/Madam,

I am PhD student at Brunel University in London carrying out research into Enhancing Special Educational Needs Learning with Semantic Web Tools ("Web 3.0 tools"). I am also working as a SEN supply teaching assistant through agencies. I would like to use web application which can support SEN students in class with English lessons. I need to observe the use of my web application and conduct interviews with the staff to evaluate the benefit of it in their teaching and learning. Involving your school in my research will hopefully provide ideas for teaching staff and help SEN research.

As your school is one of the schools that provide education for special educational needs students, I am requesting if I could conduct my research (interviewing teachers and teaching assistants) within your school environment. I would appreciate if you could spare some to support my research. I am interested in the teachers and teaching assistants experiences working with special educational needs and the current methods they use to support their learning.

I am planning to test my prototype web application in some of the sessions organized by the teachers with teaching assistants present. The prototype coves poems as part of the curriculum for literacy and I can demonstrate to you what I am planning to do in advance. There will be an interview before the session where you have the chance to look at the prototype and give your ideas about any changes required. Another interview will be conducted after the session. All the participants will be given consent forms and information sheets before the interviews. If for any reason any of the staff involved decided to change their minds or refuse to answer any question they have the right to do that. The interviews will be carried out in the location convenient to the head teacher and the staff involved in the interview and should not disturb the school in any way. All the interviews will be recorded, the information will be confidential and all the personal details will be secured.

I would be happy to add any further details about the study and the procedure I am planning to conduct at the school. You can contact me via email, telephone or mail and I will provide the below. All the observed sessions and the interviews will be arranged according to the teacher's timetable and if there is possibility to fit it within the syllabus. I have given an ethical approval by Brunel University to conduct my research in schools. I would be greatly appreciated if I could start my research in your school as soon as possible.
If you are happy to accept my research please contacts me via email, telephone or mail and we will arrange for an appointment to do all the arrangements required.

Email: Zainb.Dawod@brunel.ac.uk **Telephone:** 07984604175
Address: Information Systems and Computing, St John's 128c, Brunel University, Uxbridge, UB8 3PH, United Kingdom.
Yours faithfully,

Zainb Dawod

-The letter sent to Participants-Field Testing Annotation study

School of Information Systems, Computing and Mathematics
David Gilbert, Head of School, Professor of Computing
Jasna Kuljis, Head of Information Systems and Computing, Professor of Computing
Steve Noble, Head of Mathematical Sciences, Professor of Mathematics

Brunel UNIVERSITY LONDON

Brunel University, Uxbridge,
Middlesex, UB8 3PH, UK
Telephone +44 (0)1895 274000
Fax +44 (0)1895 251686
www.brunel.ac.uk/about/acad/siscm

11th March 2013

Dear Sir/Madam,

I am PhD student at Brunel University in London carrying out research into Enhancing Special Educational Needs with new SEN educational tool. I would like to demonstrate my web application which can support SEN students in English lessons. I need to observe the use of my web application and conduct interviews with the staff to evaluate its benefit to their teaching and learning. I completed the pilot study in two schools and I started my main study and completed my research with three schools and the feedback has been very positive. Involving your school in my research will hopefully have the beneficial impact of sharing the developments in SEN educational tools.

As your school/Nursery is one of the schools that provide education for special educational needs students, I am requesting if I could conduct my research (interviewing teachers and teaching assistants) within your school environment. I would appreciate if you could spare some time to support my research. I am interested in the teachers and teaching assistants experiences working with special educational needs and the current methods they use to support their learning. You will have the chance to discover new way of teaching children with special educational needs and try it in with your students.

I am planning to test my prototype web application in one of the sessions organized by the teachers with teaching assistants present. The prototype covers poems as part of the curriculum for literacy and I can demonstrate to you what I am planning to do in advance. There will be the chance to look at the prototype in advance and give your ideas about any changes required. The interview will be conducted after the session. All the participants will be given consent forms and information sheets before the interviews. If for any reason any of the staff involved decided to change their minds or refuse to answer any question they have the right to do that. The interviews will be carried out in the location convenient to the head teacher and the staff involved in the interview and should not disturb the school in any way. All the interviews will be recorded, the information will be confidential and all the personal details will be secured.

I would be happy to add any further details about the study and the procedure I am planning to conduct at the school. You can contact me via email, telephone or mail and I will provide the below. All the observed sessions and the interviews will be arranged according to the teacher's timetable and if there is possibility to fit it within the syllabus. I have given an ethical approval by Brunel University to conduct my research in schools. I would be greatly appreciated if I could start my research in your school as soon as possible.
If you are happy to accept my research please contacts me via email, telephone or mail and we will arrange for an appointment to do all the arrangements required.

Email: Zainb.Dawod@brunel.ac.uk Telephone: 07984604175
Address: Information Systems and Computing, St John's 128c, Brunel University, Uxbridge, UB8 3PH, United Kingdom.

Yours faithfully,

Zainb Dawod

An email from T7-M-SMO teacher at the special school to confirm the feedback about the session demonstrated at the school

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From: [redacted].312@lgflmail.org]
Sent: 29 January 2014 13:31
To: Zainb Dawod
Subject: School Website

Dear Zainb

I am in a position to answer your questions. Please feel free to contact me if you have any further questions.

In consultation with the class staff, it was felt that the session was very successful. This was made clear by the high level of pupil engagement during the lesson. The design of the prototype shows promise. The pupils were engaged by the images used. The only improvement would be to have images and words link directly to the next page faster. The prototype could be used for target groups during teaching and would be a valuable resource when finalised. The finished product, if resourced completely with topic related images etc. could help teachers present lessons by taking away the need to search for images as part of the planning stage. The ability to have instant access to images etc. and not have to rely on on-the-spot searching would contribute to the pace of the lessons and thereby minimise anxious behaviour and increase understanding. The motivation of the students would be high. Students tend to respond to ICT quite well and having a resource linked to that would be beneficial.

Yours sincerely,

[redacted]

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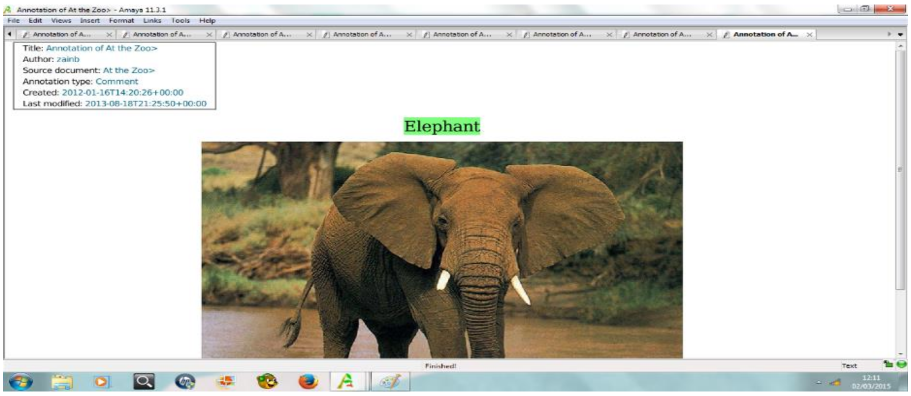
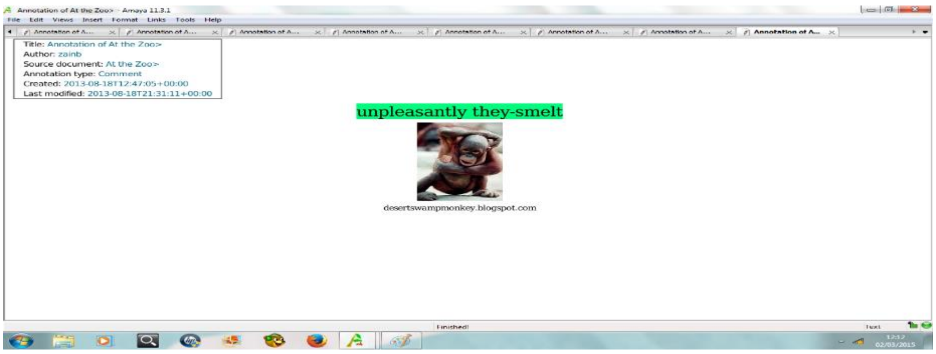
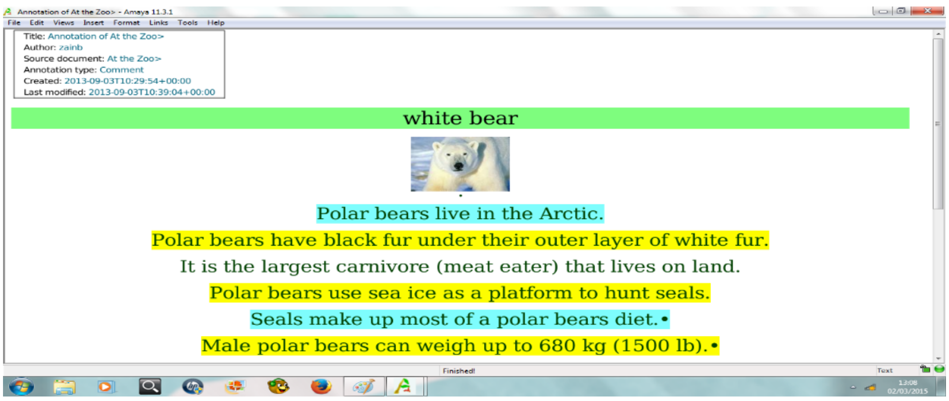
Appendix C: Demonstration Evidence of the SENTP

-SENTP in the Pilot Study



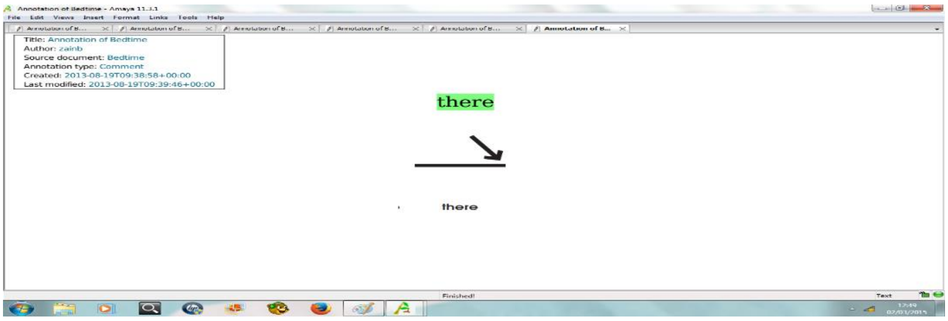


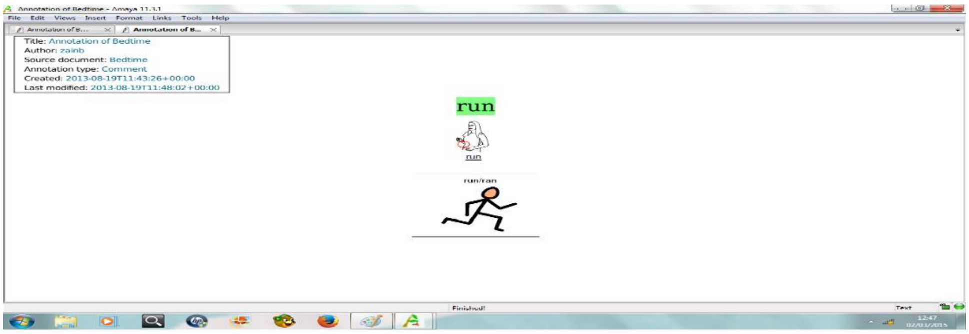
-SENTP in the Field Testing Annotation



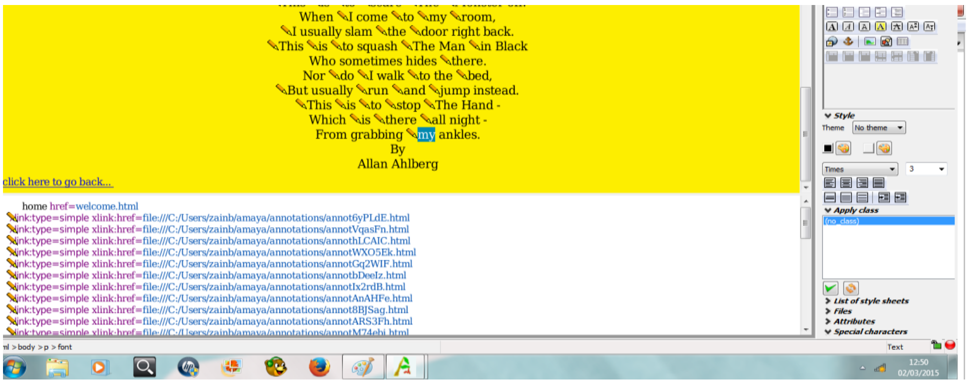
Picture and information

Examples of integrating Symbol Systems with text

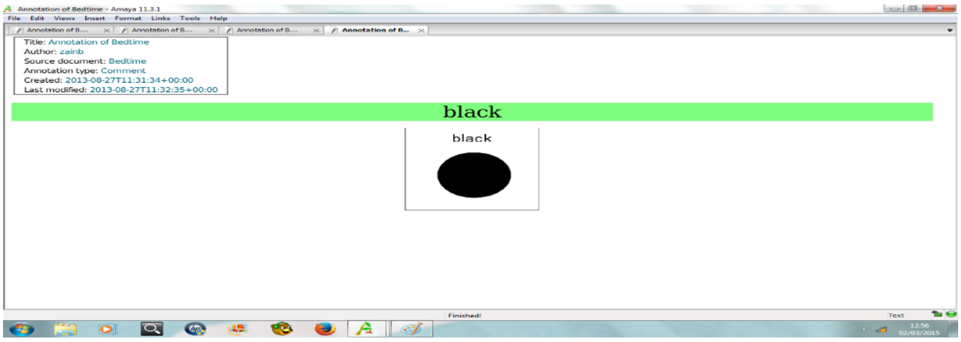


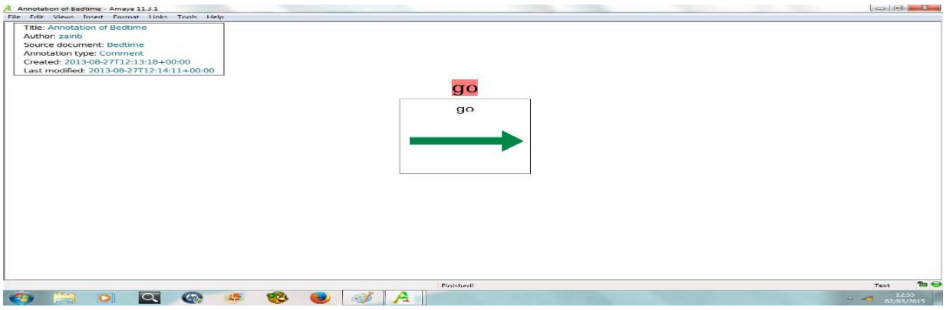


Part of the annotation with part of the code



Integrating PECS symbols with text





Appendix D: Interview questions

Pilot Study - Interview Framework

First set of interviews

Pilot study interview framework for teachers:

Below is a list of questions prepared to frame the important points required for the research purposes. If you feel, you need to stop at any point or move to the next question you are free to do that. I would appreciate if you could offer your experience to support the research. Such detailed experience is required for the research, and I am sure you will not hesitate to offer that.

A set of questions for the teacher, arranged for pre-interview in (pilot study), are as follows:

1- Which subjects are you teaching other than English?
2- Which age groups have you experienced teaching?
3- Have you had any special training to teach SEN students?
4- What type of special needs have you experienced teaching?
5- How many teaching assistants do you normally have in class?
6- Can you describe your teaching methods used to teach poems? How much is the internet involved in your teaching?
7- How do SEN students use the internet with their learning and, in particular, learning poems?
8- What type of technology, CD, font, colour, etc. do they use when they learn poems?
9- What kind of problems do you face when you teach poems to SEN students?
10- What type of support do they need?
11- To what extent can the assistant collaborate in supporting the students' learning with their poems?
12- What you will do if you end up with less staff for any reason?
13- What are the methods you use to overcome this problem?
14- Will you change your plan sometimes to support everyone?
15- Do you think using the cards sometime takes a lot of time to work with the lesson requirements and if so why?
16- Does the assistant share her/his experience and difficulties regarding the progress of SEN learning?

17- Do you always get a well-trained assistant for SEN students?

18- Do you think adding Makaton symbols, PECS symbol, Widgit symbols, extra information and images for each poem would help supporting SEN learning? Require less assistant time? Replace the assistant? Help with an inexperienced assistant?

19- Which one of the above do you consider more important?

20- What is the difference between the support you need in teaching poems and other English topics?

21- Can you manage the time during sessions/what do you do if you do not have any assistant available? What type of problems would you have? What is the most urgent case in which you need support during your teaching sessions?

22- Do you prefer to use the internet to support your learning methods? What other methods do you use?

23- What are your current concerns when you plan your lesson?

24- What are your current concerns in class?

25- Are there any problems you think might affect your teaching?

26- What do you consider as a major issue you need to solve to improve the teaching in your class?

A set of questions for the teaching assistants arranged for pre-interview in (pilot study) are as follows:

1- Which subjects do you normally, help with?
2- How long have you had experience of helping students during English sessions?
3- What training have you had to help SEN students?
4- How long have you had experience in helping SEN students?
5- -How many other teaching assistants support SEN students in class?
6- -How do you describe your current job in helping SEN students?
7- How you can support students while they learn poems?
8- Do you use one of the symbol systems such as Makaton, PECS or any other choices on cards?
9- Do you find it difficult to show all the required symbols during the lesson?
10- Do you think if you support the students with symbols cards, it might disturb others and it is difficult to support more than one student at a time?
11- -What category of SEN students have you had experience in assisting?
12- Which age group have you had experience assisting?
13- Do you use the internet to help SEN students learning poems? Do you use it in general in other sessions you have helped in before? Which subject was that?
14- -Do you share any difficulties or problems you are facing with SEN students, the teacher or carers regarding their learning progress?
15- -What you will do if you end up with less staff for any reason?
16- -What are the methods you use to overcome this problem?
17- What are your current concerns when you plan your lesson?
18- -What are your current concerns in class?
19- -Are there any problems you think might affect your teaching?
20- -What do you consider as a major issue you need to solve to improve the teaching in your class?

Questions for post interview (in pilot study) for the teachers:

1- Do you think adding Makaton, PECS, Widgit symbols, extra information and/or images used with SENTP would help SEN students in learning poems?
2- Do you find the prototype Web application useful?
3- Do you think the prototype would give you the chance to use different types of supporting methods instead of using one or two?
4- Do you think you will choose the most convenient support depending on the disability type?

5- Do you think it may replace the use of the cards to some extent or reduce their use?
6- To what extent do you think it may reduce the pressure on the teacher who needs to support the whole class at one time?
7- Do you think you would get better results (understanding) using the prototype?
8- Are the lessons more manageable?
9- Do you think the prototype is more efficient to use?
10- Did you like the design of the prototype? Are there any changes you suggest?
11- Do you think it helps in running the session smoothly?
12- Do you think it might replace the assistants/help the assistants? Do you think it might reduce the number of the assistants in class? Alternatively, replace other teaching recourses, such as the cards?
13- Do you think you can use it in other topics? What topics you suggest it could benefit from this prototype?
14- What kind of problems did you find during the session?
15- Do you think it has increased the motivation of the students during the session?
16- Do you think using the system would reduce behavioural problems?
17- Can you give the grade of support that such system will provide to SEN students?
18- What kind of improvements would you suggest to improve the prototype?
19- Do you suggest adding any other type of annotation?
20- What issues the prototype may solve?
21- Do you have any concerns using the prototype?
22- In future, would you choose to use the prototype?

Post interview questions for teaching assistants:

1- Do you find that adding Makaton symbols, PECS symbol, Widgit symbols, extra information and/or images as would help SEN students in learning poems?
2- Do you find the prototype Web application useful?
3- Do you think it may replace the use of the cards to some extent or reduce their use?
4- To what extent do you think it may reduce the pressure on the teaching assistants who need to support more than one student at a time?
5- Do you think it would allow you to support more than one student during the session using the prototype?
6- Do you think you got better results (understanding and achievement) by using the prototype?

7- Did you like the design of the prototype (colours, font, images etc...)? Do you have any suggestions for change in future?
8- Do you think it helps in running the session smoothly?
9- Do you think it replaces or reduces other resources you use to support SEN students during the sessions such as using the Makaton, PECS cards?
10- Do you think you can use it when assisting in other subjects?
11- What kind of problems did you face when using the prototype? How do you think we can overcome these problems?
12- Do you think it increased the motivation of the students during the session?
13- Do you think using the system would reduce behavioural problems?
14- Can you give a grade of the support that such system will provide to SEN students?
15- Do you think adding Makaton symbols, PECS symbol, Widgit symbols extra information and/or images would help SEN students in learning poems?
16- Do you think it improve the education progress for special educational needs students?
17- Do you suggest adding any other type of annotation? What kind of improvements would you suggest improving the prototype?
18- What issues the prototype may solve?
19- Do you have any concerns using the prototype?
20- Would you choose to use the prototype in future?

Field Testing Annotation Interview Framework

A set of questions for teachers' interviews, as follows:

1. Which subjects are you teaching? (Warm up question and to confirm the teacher's background experience)
2. Which age groups have you had experience with? (Warm up question and to confirm the teacher's background experience)
3. Have you had any special training to teach SEN students? (Teacher's background experience)
4. What type of special needs have you experienced teaching? (Teacher's background experience)
5. What is the difference between the support you need in teaching poems and other English topics? (Poems require intrinsic load)
6. Can you describe your current teaching methods used to teach special educational needs (SEN) learning poems and in other subjects? (OBJECTIVE 1)

7. What are the current difficulties in lessons that effect on increasing the cognitive load for SEN students? OBJECTIVE 1
8. Do you use the Internet to teach poems? How? (CONSISTENCY)
9. Do you find teaching poems more difficult than other subjects? Why? What type of support do they need? (Intrinsic Load-OBJECTIVE 1)
10. How many teaching assistants do you have in class? Can they cover all the work required in class? (Link with objective 2)
11. To what extent does the teaching assistant collaborate in supporting students learning poems? (OBJECTIVE 1)
12. Do you always get well trained assistants for SEN students (Makaton, PECS, WIDGIT OR SIGN LANGUAGE)? Have you had any child who trained with one of the symbol systems that your staff has never used before? How did you handle the situation? OBJECTIVE 2
13. Do you have any training regarding one of the symbol systems such as Makaton, PECS or Widgit)?
14. How can lack of attention affect class learning? Do you have a lack of attention problem in your class? OBJECTIVE 1
15. Do you find the materials/topics are difficult to explain to SEN students? Why? OBJECTIVE 1
16. Do you think finding the right resource, or preparing resources, are one of the problems in teaching SEN students poems or other subjects? Why? OBJECTIVE 1
17. Do you consider the student learning level or his cognitive load (the load affecting on working memory) when preparing materials for special educational needs (SEN) in class or preparing for their presentations?
18. Do you think the prototype can support complex materials if it is adapted for other subjects such as RS, History etc.? (OBJECTIVE1, reduce intrinsic cognitive load) (COGNITIVE LOAD: the status of working memory in learning situations)
19. How far is the lesson adapted to each student's individual needs?
20. How does the prototype focus on individual needs and how we can consider for further improvements?
21. Do you like the combination of choices in my prototype? Which combination is the most beneficial to your student? Why? Does the combination simplify the task?
22. Which combinations are the most beneficial to the specific case of special needs students?
23. Can you suggest a combination of any of the choices provided in the prototype? Why?

24. Do you think using the prototype could replace assistants? Support assistants? Could support inexperienced assistants? Require less assistance? OBJECTIVE 2
25. Do you think combining images with text for each poem would help supporting SEN learning? Require less assistance? Could replace assistance? Could help with inexperienced assistants? How? OBJECTIVE 2
26. Do you think using text only would be an effective way to teach poems for special educational needs learners? OBJECTIVE 1
27. Do you think using images only would be an effective way to teach poems for special educational needs learners? OBJECTIVE 1
28. Do you think using any of the symbol systems on its own would be an effective way to teach poems for special educational needs learners? OBJECTIVE 1
29. Can you describe how the prototype can support special educational learners with their education?
30. Can you describe how the prototype can support the teacher and teaching assistant?
31. Do you think to choose simple, clear, bright colours and short poems is more efficient for a successful lesson with better results? OBJECTIVE 2
32. Do you think it may reduce the pressure on the teacher who needs to support the whole class at one time? How? OBJECTIVE 3
33. Do you think it replaces or reduces using other resources to support SEN students during the sessions, such as using the Makaton, PECS cards? OBJECTIVE 3
34. -Do you think it may replace other resources you use such as the cards, pictures and the internet? OBJECTIVE 3
35. Do you think it may support other resources such as props? How? Objective 3
36. Do you think presenting images, symbols or both with text in the same area of the screen is more beneficial for special educational needs learning? Why? OBJECTIVE 2
37. Do you think presenting images, symbols or both with words at the same time is better than presenting them simultaneously for an effective special educational needs lessons? OBJECTIVE 2
38. -Do you think you would get better results (understanding) using the prototype? Are the lessons more manageable? How? OBJECTIVE 3
39. -Did you like the design of the prototype (colours, font, images etc...)? Are there any changes you suggest? Which part is the most useful part in class for the teacher? REF: FUTURE MODEL

40. -Do you think you can use it in other topics? What topics you suggest it could benefit from this prototype? Why? OBJECTIVE 3
41. Do you think it has increased the motivation of the students during the session? How? (OBJECTIVE 3)
42. Do you think using the system would reduce behavioural problems? How? OBJECTIVE 3
43. Do you think you will get better class management using SEN prototype? How? OBJECTIVE 3
44. Do you think the prototype can save preparation time for teachers/teaching assistants? How? OBJECTIVE 3
45. Do you think presenting the poems with bold, italics, different types of heading style support the learning of poems for special educational needs learners? OBJECTIVE 2
46. Which type of special educational needs do you think can most benefit from this prototype? Why? OBJECTIVE 3
47. Do you think it is important to explain at the beginning of the session how the prototype works? (Goal free effect- Pre- Training Principle)
48. How much you think the prototype can enhance special educational needs (SEN) learning? OBJECTIVE 3 and OVERALL THESIS QUESTION
49. -What kind of the limitations did you experience with the prototype during the session? REF: FUTURE MODEL
50. - What kind of improvements would you suggest improving the prototype? REF: FUTURE MODEL
51. -Do you think it can help on improving the educational progress for special educational needs students? OVERALL ANSWER OF FINAL RESULTS
52. -In future, would you choose to use the prototype? Why? OBJECTIVE 3 and FINAL RESULTS
53. Do you have any comments to add?

A set of questions for teaching assistant interviews as follows:

1. Which subjects are you teaching? (warm up question and to confirm the teaching assistant’s background experience)
2. Which age groups have you had experience with? (warm up question and to confirm the teaching assistant’s background experience)

3. Have you had any special training to teach SEN students? (teaching assistant's background experience)

4. What type of special needs have you experienced teaching? (teaching assistant's background experience)

5. What is the difference between the support you need in teaching poems and other English topics? (Objective 1 Poems require intrinsic load)

6. Can you describe your current teaching methods used to teach special educational needs (SEN) learning poems and in other subjects? (OBJECTIVE 1)

7. What are the current difficulties in lessons which effect on increasing the cognitive load? OBJECTIVE 1

8. Do you use the Internet to teach poems? How? (CONSISTENCY)

9. Do you find teaching or support teaching poems more difficult than other subjects? Why? What type of support do they need? (Intrinsic Load-OBJECTIVE 1)

10. Do you think you can cover all the work required in class?

11. To what extent do teaching assistant collaborate in supporting students learning poems? (OBJECTIVE 1)

12. Are trained to support SEN students with (Makaton, PECS, WIDGIT OR SIGN LANGUAGE)? What about other assistants? Have you had a SEN student who needs to use any of the symbol systems? How you handled the situation? OBJECTIVE 2

13. What are the current measures of cognitive load for special educational needs (SEN) learners? OBJECTIVE 1

14. How can lack of attention affect class learning? Do you have some students with lack of attention problem in class? OBJECTIVE 1

15. Do you find some of the materials/topics are difficult to explain to SEN students? Why? OBJECTIVE 1

16. Do you think finding the right resource/preparing the resource are one of the problems to teach SEN students poems or other subjects? Why? OBJECTIVE 1

17. Do you consider the student's learning level or his cognitive load (the load affecting on working memory) when preparing materials for special educational needs (SEN) in class or preparing for their presentations?

18. Do you think the prototype can support complex materials if it is used for other subjects such as RS, History etc.? OBJECTIVE1 (reduce intrinsic cognitive load) (COGNITIVE LOAD: the status of working memory in learning situations

19. How far is the lesson adapted to each student's individual needs?

20. How does the prototype focus on individual needs and how we can consider further improvements?

21. Do you like the combination of choices in my prototype? Which combination is the most beneficial to your student?

22. Which combination is the most beneficial to the specific case of special needs students? Why? Does the combination simplify the task?

23. Can you suggest a combination of any of the choices provided in the prototype? Why?

24. Do you think using the prototype could replace assistants? Support assistants? Could support inexperienced assistants? Require less assistance? How? OBJECTIVE 2

25. Do you think using text only would be an effective way to teach poems for special educational needs learners? OBJECTIVE 1

26. Do you think using images only would be an effective way to teach poems for special educational needs learners? OBJECTIVE 1

27. Do you think using any of the symbol systems on its own would be an effective way to teach poems for special educational needs learners? OBJECTIVE 1

28. Do you think to choose simple, clear, bright colours and short poems is more efficient for a successful lesson with better results? OBJECTIVE 2

29. Do you think presenting images, symbols or both with text in the same area of the screen is more beneficial for special educational needs learning? OBJECTIVE 2

30. Do you think presenting images, symbols or both with words at the same time is better than presenting them simultaneously for an effective special educational needs lessons? OBJECTIVE 2

31. Do you think it may reduce the pressure on the teaching assistants who obliged to support a group of SEN students class at one time? Why? OBJECTIVE 3

32. Do you think it replaces or reduces using other resources you use to support SEN students during the sessions such as using the Makaton, PECS cards or images? OBJECTIVE 3

33. Do you think it may support other resources such as props? How? Objective 3

34. -Do you think you would get better results (understanding) using the prototype? Are the lessons more manageable? How? OBJECTIVE 3

35. -Did you like the design of the prototype (colours, font, images etc...)? Are there any changes you suggest? Which part is the most useful part in class or for the teaching assistants? REF: FUTURE MODEL

36. -Do you think you can use it in other topics? What topics you suggest it could benefit from this prototype? Why? OBJECTIVE 3

37. Do you think it has increased the motivation of the students during the session? How

OBJECTIVE 3

38. Do you think using the system would reduce behavioural problems? How? OBJECTIVE 3

39. Do you think you will get better class management using SEN prototype? How?

OBJECTIVE 3

40. Do you think the prototype can save preparation time for teachers/teaching assistants? How? OBJECTIVE 3

41. Which type of special educational needs do you think can most benefit from this prototype? Why? OBJECTIVE 3

42. Which type of special educational needs do you think can most benefit from this prototype? OBJECTIVE 3

43. Do you think presenting the poems with bold, italics, different types of heading style support the learning of poems for special educational needs learners? (OBJECTIVE 2)

44. Do you think it is important to explain at the beginning of the session how the prototype works? (Goal free effect- Pre- Training PRINCIPLE)

45. How much you think the prototype can enhance special educational needs (SEN) learning? OBJECTIVE 3 and OVERALL THESIS QUESTION

46. -What kind of the limitations did you experience with the prototype during the session? REF: FUTURE MODEL

47. What kind of improvements would you suggest to improve the prototype? REF: FUTURE MODEL

48. -Do you think it can help on improving the education progress for special educational needs students? OVERALL ANSWER OF FINAL RESULTS

49. -In future, would you choose to use the prototype? Why? (OBJECTIVE 3 and FINAL RESULTS)

50. Do you have any comments to add?

Appendix E: Transcripts

Pilot Study

Date:	27/3/2012
Location:	year7 class
Time:	11.00
Post:	SEN Teacher -T1

Q1-R- Which subjects are you teaching other than English?

T1: I teach maths, humanities, ICT, RE.

R: So, are you responsible for the whole class and all the subjects?

T1: Most of them not all of them, about 90% of the subjects I teach. It is very primary based, so the only subjects that are taught by alternative teachers are Science, PSHE and Citizenship and PE and Food Technology.

Q2-R- Which age group have you had experience teaching?

T1: In my previous career? Primary, I taught from foundation to year 6, and now I am teaching year 7 Foundation, which is reception. I am primary based, primary trained teacher not secondary trained teacher, and the reason why I am employed here is because most of the students operate on the Primary Curriculum.

R: They study keystage1 and keystage2? no

T1: There is keystage3 but they mainly operate on the primary curriculum which is keystage2

Q3-R- Have you had any special training to teach SEN students before?

T1: The only training I had was the experience teaching in the British school abroad, and here I had ongoing training on Autism and dealing with children with Autism in the classroom, dealing with children who have BED (Behaviour Emotional Disorder).

R: So, these types of courses are available in school from time to time?

T1: Yes, sometimes in house, and sometimes we are sent out of school, but mainly they're in house.

R: And you **never had any courses in Makaton or PECS**?

T1: **No**, the school does not encourage these types of courses, we do not really use them.

R: So, you do not use them?

T1: Not really

Q4-R- What type of special needs do you **have experience** in teaching?

T1: **A range of issues** such as ASD, complex syndromes, global learning difficulties, BED kids, ADHD

R: And you do not have deaf and blind pupils here?

T1: We have one student who is the only visually impaired blind student (Moryn), she is in the sixth form, she is further up the school, she is in the upper school but I have never come across teaching a blind or deaf person. She gets different support

R: What about deaf?

T1: No definitely not

R: But they might have some problems with their eyes?

T1: Yes, we have visual impairment, and to different degrees. I have a child in my class currently who has slight visual impairments; however, it is nothing major I would say.

Q5-R- How many teaching assistants you normally have in class?

T1: Currently, I have two teaching assistants.

R: All the time?

T1: Yes, because one of them is assigned to one of my pupils here who has one to one, so that TA is really assigned to one of my pupils. One of my teaching assistants is assigned for him that is why I have two, but I normally have one in each class.

R: You normally have one?

T1: Yes, per class, so the reason I have two is because one TA was assigned to one of the pupils one to one. That is why I have two.

R: Ok, so one teaching assistant allocated to specific student?

T1: Yes, to specific individual.

R: the second teaching assistant is for supporting the rest of the class?

T1: Yes, the second teaching assistant is for general class support.

R: Does this child have autism?

T1: No, umm...Just general medical and learning difficulties, more than medical needs, more than learning difficulties.

Q6-R- Can you describe the teaching methods you use to teach poems? How much the internet is involved in your teaching?

T1: I would use the interactive whiteboard to bring up the poem; we would normally have books to accompany those, and the use of visuals as well...visual aids.

R: Like, do you mean pictures?

T1: Sometimes pictures to assist, yes.

R: Do you use them yourself or the assistant?

T1: I use it myself and so does the assistant. We both would use it.

R: do you use the internet to teach your students?

T1: Occasionally, yes, but it depends on what I am teaching, and what is the topic. It depends on what I am teaching again.

Q7- R- How do special educational needs students use the internet with their learning and in particular, learning poems? Do they use it for example, after you explain or demonstrate? do they use the internet?

T1: They use the internet a lot, it wouldn't necessarily be used for the poem, they might use the computer to aid, we might have things put on the computer for them, programs or they might use word documents.

R: So, this is the following question. —Q8-what type of technology they use when they learn poems? So basically, they use the internet to research things? Only for research?

T1: Well, for lots of things, to research, to go on to games, online games, and educational games which would include learning topics.

R: not poems specifically?

T1: No not poems, we haven't had that experience yet anyway. We haven't had experience of using the internet for poems.

Q8-R- What type of technology do you use when you teach poems? You mentioned CDs?

T1: No not CDs it would be either programs already purchased the school. It could be programs that we have…umm. or documents created by myself and put them on the system.

R: By the teacher

T1: Yes

R: Do you prefer some fonts or colours?

T1: I think it is very important the colour, so, as I said, I haven't taught poems yet because it is in our summer term curriculum, but if I was, definitely, font, colour, background is very very important in teaching. Changing colour and font is to make things more lively, to engage the students, to direct them in specific part in the poem, so that would be very important thing.

Q9-R- What kind of problems do you face when you teach poems to SEN students?

T1: To understand the underlying meaning in the poem, so with some of our ASD pupils, they would understand what they read as literal. They understand it at face value, as it is literal not the underlying meaning of what the author's trying to get out, that is quite difficult for them to understand.

R: ok

T1: Yhaa, so it depends on the poem, and we would select a poem that is appropriate. I wouldn't select a poem that would say I jump in the air to do whatever, because they would think they would jump in the air, in the sky. I am not. They would understand things that are concrete not abstract. Abstract understanding in poems is very difficult for special educational needs in general, especially autistic kids. That's the danger when you teach poems, you've got to explain what they mean.

R: Ok

T1: Especially autistic, because if you had a poem that say I jump in the air to do whatever, they think that the person jumps in the air, in the sky, in the cloud, so it can't be abstract, if it's abstract it doesn't seem right. They cannot get it.

R: Therefore, that is the main concern for you.

T1: Yes, it understands the meaning of the words. People are quite good with rhyming words.

R: You overcome this problem by selecting poems?

T1: Yes, poems that are appropriate and we build on it, so you know until we work up towards the different meanings or have underlying meanings. So, we build on that, and because year 7 will be the lowest in the school, we would start off with something very very basic and then they work on that as they walk up in the school. That how it is done.

Q10-R- What type of support do they need? When you teach them?

T1: Umm... With reading, most of them it depends on the reading level, so definitely reading, umm... Some pupils they can read but with writing...some students need support with writing. They need support with reading and writing. Yhaa, so some with writing and we have got varying needs, so some with reading and writing and some have only problems with reading but not writing and some have problems with writing but not reading.

R: And understanding as well?

T1: Yhaa, and understanding obviously, definitely. So, to understand what they read. So their comprehension of what they read.

Q11-R- To what extent can the teaching assistant collaborate in supporting the students' learning with their poems.

T1: Umm... Huge support, because they can take pupils away, it doesn't have to be main teaching, they can take them off in small groups and again we differentiate the activity to match their learning needs. That is what the primary need is for our teaching assistants are to differentiate. We differentiate work further, and they would sit with that group, and use visual support or whatever is needed to help the pupil understand their learning objective. Their learning intention.

R: Excellent, so you think it is a huge support.

T1: Definitely.

Q12-R- what you will do if you end up with less staff for any reason? For example, you normally get two and you get one? And this one supports specific SEN?

T1: I teach the group that I feel would understand and trying to deliver, and the pupils who will absolutely struggle will have work differentiated to suit their levels, and so they can get on and do something independently, not necessarily what I am teaching in class.

R: So, you will change your plan?

T1: I sometimes don't change my plan and I do the ones that can get on by themselves after I have taught, will do work independently and I will act as the TA and sit with the pupils that would need that support in groups, so that, after I have done my main teaching I swap roles.

R: But you will struggle?

T1: Definitely, no doubt... There is no teacher that would say I will not struggle but we will do our best. We manage in the end.
R: So..umm you explained part of the following question–Q13-what are the methods you use to overcome this problem? Q14-R-Which is to change plan?
T1: Yes. I would differentiate the work further, and I would divide the groups in such a way that I can manage the class on my own. I would have the less able that would definitely struggle on their own. So the ones that do need adult support will be with me, and the ones that are able to get on will have a worksheet or an activity paper on their own. I would then switch roles as I said, if I needed to do that lesson and didn't want to change the plan. I would carry on with that lesson but then I would switch roles, so the pupils that I know are more able to get on by themselves, will get on by themselves rather than having my support because they would have my support if I had a TA, so I get them to work on their own.
R: So just sometimes, stay with your plan? depends on the lesson?
T1: Yes, it depends on what it is, if it is practical activity that it is impossible to do on my own, obviously, I have to change plan, but we never on our own in the school, we always get cover. But sometimes there is a disaster, like once heavy snow or something like that. The school then closes. We have a policy to have a certain amount of staff ratio to pupils because of the needs of the kids in the school, and sometimes there are teachers, yes, they are on their own, and the reason they are on their own is because the group they have can manage with one adult. The group they know will never manage on their own because they need that support are never left unsupported.
R: Do you think you sometimes **need more than two assistants**?
T1: **Definitely,** there are at least four pupils in my class that ideally work very well on one to one bases.
R: So, you think you need **more than two?**
T1: **more** than two members of staff in the classroom
Q15-R- Do you think using the cards sometimes takes a lot of time to work with the lesson requirements and why? Makaton cards or PECS cards. Do you think this would take a lot of time to work while you demonstrate, and the assistant should show some cards? Does this happen to you before?

T1: No, because we organise our lesson as I said in such a way that it works, otherwise this means I haven't planned my lesson well.

R: This is regarding the teaching assistant's work not yours. If it is the teaching assistant, The role of the teaching assistant

T1: No, because the teaching assistant will work at the pace of the student, she does not have to work at the same pace as myself. For example, if I am teaching a poem and this poem and this child could not access the way I am teaching the poem to the whole class, then my teaching assistant will go away and teach this poem in a different way with this pupil at a different pace.

R: Other type, later on. After your demonstration.

T1: No, it could be while I am demonstrating. She is off teaching the poem in a different way, doing an activity around in a different way.

R: So this is the way you use? Other than this you will not have somebody who's sitting while you demonstrate because I have seen this in other school and they get a card and show.

T1: Sometimes, they do that but if they didn't understand it after my demonstration they would to explain it further.

R: you think using the cards taking a lot of time just this one? Does it take a lot of time? That is why they take them individually.

T1: Umm...Yes, it does probably take time. It does take time.

R: So you think it does take a lot of time and that is why she takes the child later to explain further? They cannot get everything.

T1: Yhaa. However, it is very hard to answer because it depends on what you giving to that pupil, if you are giving a poem that is not appropriate to that pupil this mean I am not doing my job properly. I am still not differentiating to accommodate to that pupil. Let us assume that the poem is for this age and for this level and appropriate but you have different abilities. One physical problem, one autism and one needs Makaton cards.

They might not do what I am doing, they might do something completely different, if I know they can't access that poem, they will work on individual targets. Their learning targets.

R: But you never have a problem of something that you have to demonstrate to everyone and at the end you (if it is poems or any other topics) think it does take time.

T1: Yes it does.

Q16-R- does the assistant share her/his experience and difficulties regarding the progress of SEN learning?

T1: Yes definitely, yes definitely.

Q17- R- Do you always get well-trained assistants for SEN students?

T1: Yes.

R: Even for the cover?

T1: We do not have a lot of cover in this school, it is all managed internally. We have a high ratio of teaching assistants, so we have over 60.

R: So they are experienced

T1: Most of them they are very well experienced…very well trained.

Q18-Do you think adding Makaton symbols, PECS symbols, Widgit symbols, extra information, sound or images for each poem would help supporting SEN learning? Require less assistance? Replace assistance? Help with inexperienced teaching assistants? This is a general question, from your experience.

T1: Not all of them. Again, not all of them...I have experience with my son, who is in the school...he is my oldest boy... He has special educational needs...Learning difficulties...But symbols don't help him.

R: No I mean, because there is a difference, not only symbols

T1: Some of them... Yhaa.

R: Like Makaton symbols, PECS symbols, Widgit symbols, extra information, sound or images, you mentioned images.

T1: That is what I am saying...Some work for some pupils some don't work for the others.

T1: Of course, it does... of course it does...Generally, if you look at it in general…yes.

R: Yes, but not all of them.

T1: Of course, because they are with different abilities so at the end some they need this and some they need the other methods. Yes, so you look at the global picture.yes.the answer is yes.

R: Do you think it might **reduce the assistance** required? If you have something like that. For example, you can manage the class with two TAs instead of getting more teaching assistants. You have got two and you think you need four...But with the prototype, you can cope with two. Do you think so?

T1: **Yes**.yes…sometimes yes. Sometimes.

R: Do you think it might **replace the teaching assistant**?

T1: **No.**

R: Definitely.

T1: No.

R: Do you think it might **help with inexperience assistant**? In general?

T1: **Yes. Definitely**.

Q19- Which of the above resource forms you consider more important? For these types of support from your experience.

T1: **Visuals...Images...Visuals...visual images.**

Q20-R: What is the difference between the support you need in teaching poems and other English topics.

T1: Umm... Not much difference...Umm...**Poems as I said can be very abstract, other things we teach in English are not abstract**.

R: Straightforward.

T1: **Straightforward,** so...Umm...**With poems yes you need more support because of the way they are constructed, the way the poem's written, you can get hundreds of different types of poems and styles, so it would be a bit more complex possibly more than other areas in English.**

R: You think it might be more difficult.

T1: Yes.

Q21- R: Can you manage the time during sessions. What if you do not have any assistant available? What type of problems would you have? What is the most urgent case in which you need support during your teaching sessions? Can you manage the time during the English lessons? For example, this does effect on the timing? When you teach all these different type of learning difficulties.

T1: Umm..yes they do take more time, but again it depends on the poem you demonstrate to the kids , so there is no point getting a Shakespeare poem for example, teaching it to these kids and it won't…, and there are thousands of poems out there… you would always choose one that is appropriate level wise not necessarily age appropriate, well age appropriate as well, but definitely level wise, umm..to match their ability, so again it does depend, it all depends on what they are subjected to.

R: But you think you manage the time because you choose something suitable?

T1: Umm...most of the time yes. Sometime no... Sometimes you do not get it all right and as I said if the poem is very difficult to explain, yes it does take more time. Depends on the poem? Depends on the mood of the students. Depends on the poem you choose. Depends on what engages the children, depends on their understanding of the poem, there are lots of other factors that come into time management and what happens in class.

R: What if you don't have any assistant available?

T1: **I had to teach a poem**, I would have the pupils that understand.

R: So you manage it in the other way like you might either change the plan or change the role.

T1: Yes, I would adapt the work to suit them.

R: What type of problems do you have other than this, in general with special educational needs during class, during teaching poems, that I didn't, for example, mention in general?

T1: As I said before, it is **understanding,** what is the author trying to get you to understand really.

R: **Do you have problems engaging them**, like some people especially with ADHD, you find difficult to make them engage more?

T1: **Yes, yes...Yes...Again**...That is why you have to choose a poem you know that is suitable for your pupils in class. if you know the poem will be boring, dull and not engaging, especially for boys, then you made a wrong choice as a teacher, it is very important to choose the appropriate poem. Choose the appropriate poem...Umm.

R: What is the **most urgent case** in which you need support during your teaching lesson?

T1: To support with **behaviour... and understanding** for the ones that have low understanding or communication problems.

R: Do you use **the internet** to support your learning methods at some point?

T1: **Not** really.

R: What **other methods** you use? Programs, the school purchases …some educational programs?

T1: No, I **use a combination**.

R: What is your **current concern** when you plan the lesson in English?

T1: Umm...**Accommodating for the huge needs, the varying huge needs** that I have in my class, umm…so accommodating for everybody's needs individually, they all very very different needs.

R: Different needs...

T1: Very different, the needs are quite dramatic

R: That is why you think you need more than two assistants. Are there any problems you think might affects your teaching?

T1: Yes, the **children's moods** and how they have come to the class, if something happened at home, how they come in... Umm, you know, if they are not well, umm**...if… the structure changed**, the **structure is very very important to our pupils**, if the structure has changed, or **has been disrupted, structure and the routine** of the whole day, if it is changed.

R: Especially for autistic people?

T1: For all the kids, not just for the autistic. **If the structure is gone for a day or they have new visitors in, new people out, or the timetable is not followed.**

R: I hope I didn't cause any problems today?

T1: No, **they are quite good**, but if the structure changed, the routine has changed because they stick to a quite structured routine, that throws off things in teaching.

R: What you consider as a major issue you need to solve to improve the teaching in your class in general?

T1: Change the teacher, hahaha. **More training in different areas.**

R: Training in which thing?

T1: Umm.I think because we have **growing autistic population in this school, I think more on having autism friendly classrooms,** will be one for me.

R: Ok, thank you very much for your time

T1: That is ok.

R: Thanks, a lot

Field Testing Annotation - Interview 16

School:	Moorcroft school,	Group: 8 SEN students
Place:	free room,	Name: T7-M-SMO
Position:	SEN Teacher,	Time: 1.00pm

R: I will be asking you a few questions regarding the demonstration that we did today?

T7-M-SMO: Right, that is not a problem

R: which subjects are you teaching, basically? I know you're looking after the whole class?

T7-M-SMO: well, the class stays with me for most of the day, so I will teach them Maths, English, PE, and we also have Special Projects that include the subjects like ICT, PSHE, C, Science and Religious Education, so rather than having separate subjects all the time, we just touch on the bits and pieces in a Special Project.

R: different subjects?

T7-M-SMO: For example, this half term, is the seasons, so in science, we look at light and dark, maybe hot and cold that kind of thing from the PSHE C point of view, we look at what clothes we would have wear when it's hot, what clothes you would wear when it's cold, and the RE that comes with the seasons is Christmas, and celebrations.

R: Every occasion you have a different topic to cover. Which age group have you had experience with?

T7-M-SMO: I've had experience with upper primary school, so year 6, and the secondary school all the way from year 7 to 11, from 11 to 19years.

R: have you had any special **training** to teach special needs?

T7-M-SMO: **I haven't**, everything I have **learnt through experience**, I have gone on courses but **I haven't had any specialized training**.

R: not specialized within the school? What **type of special needs have you experience** teaching?

T7-M-SMO: **a wide range**, we've got profound, multiple learning difficulties, students who also have underlying medical conditions, I've worked with children with autism, Down syndrome, Fragile X, global developmental delay, yes.

R: and regarding **the class today**, they are all autistic or…?

T7-M-SMO: no, **there are some with autism, there is some cerebral palsy, there is some just global developmental delay and some unspecified.**

R: because there was one who refuses to sit at the beginning, is he ADHD part of it?

T7-M-SMO: his diagnosis is mostly severe learning difficulties with global developmental delay and autistic tendencies, so it's not a specific diagnosis of autism, it's become very difficult with students in our school to get a precise diagnosis, some do of course but some of them it's really difficult to test.

R: it's become very difficult. What is the difference between the support you need when you teach poems and other English topics?

T7-M-SMO: sorry?

R: have you found a difference between when you teach poems to special needs and when you teach normal English literacy?

T7-M-SMO: no, I don't. I think the way that we present poetry and stories is supported with object of reference, images, and sounds.

R: you always **support with visuals**?

T7-M-SMO: **usually always**. I find with the poetry; the students have a greater capacity to remember what they have been learning about because sometimes if you sing it there is greater interest in it as well.

R: can you describe your **current teaching methods** used to teach special needs, you mentioned that you used visuals, pictures and things?

T7-M-SMO: we use a lot of **signing, alongside verbal instructions**, we support signing and verbal instructions with **symbols.** For students who do not know yet how to read symbols, we use **photographs**; we also use **autistic specific ways of working**, so we've got **personalised timetables** for the students, now and **next symbols**, we also use teach stations, I mean work stations where **students are encouraged to work as independently** as possible by following a colour coded schedule so you saw in the classroom we had all these trays on the top of the table, we have different colours they will take the colour of the beginning because we always work from top to bottom, left to right so they take first colour … take it out do the activity then put it away, and move on to the next one and in between that I put the work I want them to achieve but I also put things that help them with certain key skills, like I am putting some colouring in that helps them with handwriting, or have threading activities, things they can do on their own with less input from me so working towards independence.

R: working towards independency? What are the **current difficulties** in lessons that affect **increasing on the cognitive load** for special needs students?

T7-M-SMO: things like **behaviours.**

R: so you find one of the difficulties is **behaviours**?

T7-M-SMO: I think **one of the challenges** we have in this kind of school is the kinds of behaviours that we might be dealing with, the **other difficulties** are we need to run occupational therapy and physical therapy programs within the lesson time so it’s about managing a group so that there is as little impact on everyone’s learning as possible, so if a behaviour happens somebody deals with it and everyone tries to get everyone back on task.

R: Do you use the **internet** to teach poems?

T7-M-SMO: **Not so much**, I would search on them.

R: not all the time?

T7-M-SMO: no.

R: how many **teaching assistants** do you have in class?

T7-M-SMO: **four**.

R: can they cover all the work required, because I know that most of the students they need kind of one to one, isn’t it?

T7-M-SMO**: Ideally, all our students deserve one to one** but that is **not possible**.

R: not possible.

T7-M-SMO: I’ve got **eight students in my class**, **four additional members of staff** to support students’ learning and help with their personal care. Umm they...

R: they need more?

T7-M-SMO: they are very good at what they do.

R: they manage the class?

T7-M-SMO: absolutely, so if I am out now, as I am talking to you, they know the routine, they know the system; if it gets to say quarter past eleven they will probably start the next lesson for me so they can keep the routine for the children.

R: the class

T7-M-SMO: because we find that if there is dead space that is how the behaviours starts, so.

R: and they like the routine, specially the autistic students?

T7-M-SMO: ohh, yaa.

R: to what extent can teaching assistants collaborate in supporting students learning poems?

T7-M-SMO: Well, we have weekly meetings with the staff; we also meet from half past eight to nine every morning, where we talk about what is going to be learnt about during the day. If I am doing a certain topic, I will always invite my staff to suggest poems that they might like to do... umm... and they can sometimes come up with some of the ideas surrounding it as well.

R: Do you **always get well trained assistants** for special needs, I think like Makaton PECS and Widgit or sign languages?

T7-M-SMO: It's a **mixed bag really**, sometimes the assistants have got a lot of experience, and sometimes we take people who are quite new but who we can see have got scope for learning really.

R: Do you have any **training about one of the symbol systems** such as Makaton, PECS, and Widgit?

T7-M-SMO: **Yes, I have trained** in signalong which is very similar to Makaton, I also had training in the use of PECS and Widgit symbols, which we now use communicating print.

R: How can **lack of attention affect class learning**, if you have lack of attention problems, as you mentioned kind of behavioural problems?

T7-M-SMO: Yes, **the lack of attention is just the behaviour to learning aspects** that we have to deal with, we find that now we are able to engage more students for longer periods of time because of the structure that we put in the class from situation, if I write in my planning that some students will takes time out to sort of sub regulate or whatever, its fine because somebody is observing that lesson, I can justify their time out because if Ofsted or any inspector comes in, those kind of things they look for, so it's about how the teachers manage a sort of a lack of attention during lesson time.

R: do you find some topics **difficult to explain** for special needs students, some of the materials?

T7-M-SMO**: Absolutely**, when you start looking at things like **religion, social skills**, and things like that, you need to take into account where the students are and what is important to them, so we do believe in exposing students to general knowledge in the sense that we will teach them about the world around them, but we will tend to focus on the key skills that are vitally important for them, so we work on independence skills, the ability to **learn independently**, initiative, those kind of things.

R: Do you think **finding the right resource; preparing resources are one of the problems** to teach special needs poems or other subjects?

T7-M-SMO: **ohh, of course yes**, **it's about time. It's about time** because if for example you have five lessons in a day, five different poems, five different sets of worksheets, resources...etc. so that is a lot.

R: that is a lot.

T7-M-SMO: so you need to break it up a little bit.

R: Do you **consider students' learning levels or cognitive load when you prepare** the materials?

T7-M-SMO: **absolutely, yes**, we have to, that is part of how we work, so we have to take into consideration every individual pupil's ability to access what we are presenting.

R: Do you think the prototype can **support complex materials** if it is used for other subjects like **RS or history**?

T7-M-SMO**: yes**

R: Do you feel it can **support in other subjects**?

T7-M-SMO**: absolutely**, it obviously depends on the target group, but yes, I think it can support, yes.

R: How far is the lesson **adapted to each student's individual needs**?

T7-M-SMO: well: our system, actually **each student** has a personalised timetable and their targets are also personalised, so at any given time, **each student is working on something specific to their development**.

R: How the **prototype focuses on individual needs** and how we consider for further improvements, you found it successful in the session that we did in the morning?

T7-M-SMO: **I thought it was quite successful**, we supported as you saw by signing the words we knew. Well, we used a bit of drama in there, I went and hid behind the thing, so we would support with it.

R: **more than one way**?

T7-M-SMO: Yes, that is **the nature of the kind of education we do**, it has to be supported with different ways, yes.

R: To grab their attention? Did you like the **combination choice in my prototype**?

T7-M-SMO: **Yes**

R: You've seen the screen, that there is combination between pictures and text and there is...

T7-M-SMO; yes, I saw that

R: the setting that I did.

T7-M-SMO: I think that would be quite useful for a range of learners with learning difficulties, I mean because I mean our school its quite different from other schools, but I can see the benefit of that.

R: **which combination** do you feel can **most benefit** your students?

T7-M-SMO: the **images** would be more beneficial.

R: Does the **combination simplify the task**; make it more easy, simple?

T7-M-SMO: **Yes**, yes, if we are looking at students that could access it, say on their own or with support, they would be able to make choices about what they want it to learn about, so from that point of view so, yes.

R: **which combination** is beneficial to the **specific case** of special needs students, you think one combination that I put on the screen?

T7-M-SMO: Yes, choices of **pictures**.

R: You like the choices of pictures; can you suggest any combination of any choices provided. I mean, do you have **any suggestions** or you like the setting?

T7-M-SMO: no, **I like the setting**, what I am trying to do now is encourage some of my more able students to make more relevant choices about popular culture and things like that, so **I am trying to get one of my students to choose Mr Bean, as an option to help support his learning, so I would present him with photographs of different activities and Mr Bean in all those**.

R: will be the **character**?

T7-M-SMO: Yes. Although he will be watching it, it will still be an activity within the whole package of learning, yes.

R: Do you think **using the prototype** could **replace assistants**, **support assistants** or **support inexperience assistants**, I know I didn't use the Makaton or other systems but for example if you have somebody that haven't trained for Makaton, PECS or Widgit, this is what I mean?

T7-M-SMO: **Within my classroom context** for the main presentation, I would possibly **need fewer assistants because they were just there supporting with siding** but **for real individual learning to happen, I think the system could support the learning assistant with the student** for example if the prototype was on a tablet, we would always need, mostly always need, learning assistant to help the students access that.

R: In the demonstration, you think you can manage?

T7-M-SMO; **Ohh, yes**

R: **with fewer**.

T7-M-SMO: **With my class, yes** you could. Unless of course there were significant behaviour issues, there can be, but **as a presentation, I can manage with fewer, yes.**

R: Do you think using the text only would be an effective way to teach poems if you have only text?

T7-M-SMO: Not in our school setting, no. **We have very few students who can read** text.

R: Do you think a **combination of image with text** for each poem could **support special needs** required?

T7-M-SMO: **Yes**, yes. When we present symbols we always present text with it.

R: Do you think using images only would be an effective way, if it is only images?

T7-M-SMO: for **certain populations within our school images are the only access** that they have to the world around them, because s**ymbols and text would become quite meaningless to them**; **photographs would support a certain section**.

R: Do you think using any of the symbol systems on its own would be an effective way to teach poems to special needs learners?

T7-M-SMO; Once again it is very student specific.

R: Can you describe how the **prototype can support learning** with their education?

T7-M-SMO: Well, I think for the more able students it would **help them learning independently**, **some of the more able students would be able to navigate through the prototype on their own** and **they will be able to tell you what they have learnt** about, **which is very important**, for the sort of **mid-ground students** I think the **prototype can support them**, **give them a focus** and then **for the lower performing students who need a lot more support to access it** , I think you know, **colourful vibrant pictures, they probably have to be bigger** then, we are **starting to talk about students that might have visual impairments or hearing impairments** and things like that.

R: Can you describe how the prototype can support the teachers and teaching assistants briefly?

T7-M-SMO: Well, yes **it supports the beginning of the lesson**. **I would not normally do three of those poems in a row**.

R: Definitely. [laugh]

T7-M-SMO: **they were having so much fun and I mean they were enjoying** it, so what I would do, **I would use that to support initially then individual work would happen from there.**

R: Do you think to choose simple, clear, bright colours, and short poems is more efficient for successful lessons with better results?

T7-M-SMO: yes, yes, yes.

R: Do you think it may **reduce pressure on teachers** who need to support the whole class at one time?

T7-M-SMO: I think to answer that, not the context of asking all, in general, **I would say yes.**

R: Do you think it could **replace or reduce other resources that you use** for special needs students during the session, such as using PECS, Makaton cards images?

T7-M-SMO: **I don't think in our setting**, **I would never use it as replacements, it would always be supplements**.

T7-M-SMO: **I would support with signing**, yes.

R: In the prototype, I have Makaton and sign language but it was not selected for today session, …. It can support somebody who is not experienced in signing.

T7-M-SMO: Yes, **from that point of view that is very good idea**, I think **that would support learners and staff,** just to see for example **if you're going through and you saw wolf, you know maybe there is sign for wolf on there,** it could help with that.

R: Do you think **presenting images, symbols or both in the same area is more beneficial** for special needs **or you prefer to present it simultaneously**?

T7-M-SMO: I think **it depends on the students** once again. I think **our students need to present it with a photograph and a symbol with the text to have maximum impact**.

R: **in the same area or one after the other**, regarding the concentration?

T7-M-SMO: **picture, symbol, text**.

R: **same place**?

T7-M-SMO: **Yes**.

R: Do you think you would **get better results** using the prototype?

T7-M-SMO: well, potentially **yes**, if it was used effectively and whoever is using is working well with it then yes.

R: Do you think the class would be **more manageable**, part of the management?

T7-M-SMO: **Yes** it depends on the day**, as you saw there they sat for 40 minutes, half an hour to 40 minutes, you saw.**

R: that is good I didn't expect that.

T7-M-SMO: **They are a very good class for doing that**, like **at the beginning there was some unpleasant accidents** but **they are learning to manage their own behaviours** and for that class specifically**..., yes, this can be an effective way**.

R: Do you **like the design of the prototype**; are **there any changes** you suggest?

T7-M-SMO: **No, I like it, yes.**

R: **You don't have other suggestions**?

T7-M-SMO: With our students, **the choices might need to be further apart because it depends on how the student is accessing that information**. If it is not an adult doing and I want the students **to work independently** t**hey might be using touch screens,** so **if using a touch screen, they might need it further apart.**

R: Do you think **you can use it in other topics**, **which topics** do you suggest?

T7-M-SMO: **Absolutely**, you could have **any topic there really**…, you could have a sort of instead of a poem, you could have **brief write up about say life**, **the process**

of plants where you could **show a seed, sapling, bigger plant**, you could **show the leaves, that kind of thing, so science** would be one of them.

R: Do you think it could increase the motivation during the session?

T7-M-SMO: **Well, I felt they were quite motivated**, so generally, **if I had taken them straight after that and presented them with a worksheet or activity, I think they would be more interested in it.**

R: Do you think using the system would reduce behavioural problem?

T7-M-SMO: **potentially it could,** because it would be something they were interested in, and motivated by.

R: Do you think it can support the class management?

T7-M-SMO: Part of the management, definitely.

R: Do you think the prototype can **save preparation time** for teacher and teaching assistants?

T7-M-SMO: **It could definitely**, using resources that have been tried and tested is part of what teachers do because you can't manufacture new things all the time. So, we have **had to rely on PowerPoint presentations** in past, which you could make quite quickly and effectively, but **you can't go home every day and make new one**.

R: Exactly, it is time consuming?

T7-M-SMO: If something exists, it's easier to do that, **it's about how you adapt to a student's needs** and **how you will assess their learning from that**.

R: Do you think presenting the poem in bold italic, different types of heading styles supports learning poems for special needs learning?

T7-M-SMO: In our school, we tend to use comic sans.

R: One style?

T7-M-SMO: One style of font, that is only because that is closest to the writing that we are encouraging the students to learn and big enough for them to see.

R: Which type of special needs do you think can **most benefit from this prototype**?

T7-M-SMO: within our school setting, I would say across the board**, it depends on the ability of the pupil.** I wouldn't make a distinction between them. **I think it could be used across the board depending on the students' interest and access to it.**

R: Do you think it is **important to explain at the beginning how the prototype works**.

T7-M-SMO: **Yes**

R: How much do you think the **prototype can enhance special educational needs learning**?

T7-M-SMO: **Well, quite a lot,** because **it can stimulate discussion**, so you could stop half way through a poem, picture of a wolf as we did and you talk a bit about it so it's a further opportunity.

R: What kind of **limitation of the prototype** was there during the session, did you see any limitation, something you didn't like?

T7-M-SMO: umm, no, **not really** because ICT is always going to be problematic in a classroom setting, with regard to the speed that it happens, I often tried to put YouTube on it and it's not working, it's gone, finishes, doesn't it, so any problem we have would just about how it is working on the day really?

R: What kind of **improvements do you suggest** improving the prototype?

T7-M-SMO: umm **spaces between the choices, I am only thinking from the access point of view for students.**

R: **for students**?

T7-M-SMO**: Yes**.

R: not for the teachers?

T7-M-SMO: **no**, no, if it is for a teacher as resources, that is fine. **I want to use it for students.**

R: Do you think it can **help improving education progress**?

T7-M-SMO: **Yes,** of course, it's a resource, isn't it?

R: Would you **choose to use the prototype in future**?

T7-M-SMO: **well considering the reaction I got from the students today, then yes** because **they seem to be motivated and engaged**, **we had the head of the school come in and I will be interested to see what his feedback is about how the students were learning**, so I am going to **have a word with him** and see what he thought, because our **English and Maths usually uses workstations** and **I think there is space for group work as well, they work very well**.

R: Thank you very much.

Transcript [redacted]

Harrow Pre-School Language Resource

Date: 17/10/2013, Position: Key worker
Place: outside the children's room Code: TA10-M-SP-CH

R: Which subject your teaching and what kind of support you're doing in the centre?

TA10-M-SP-CH: I support them in everything. We run the morning and we help other run the morning. We do the groups, all the activities.

R: Which age group you're supporting?

TA10-M-SP-CH: They all under 5.

R: Is this the only experience, you never had any experience before, like supporting in primary or secondary?

TA10-M-SP-CH: No, I have always worked with little once.

R: Have you had any **special training** for special needs?

TA10-M-SP-CH: Yes, you know I had **Makaton,** now we do sign along, I have done **behaviour management course**, one year and we do in house training as it comes up.

R: Do you have difference between teaching poems and teaching other topics like when you teach rhymes, do you find difference or you don't have difference?

TA10-M-SP-CH: I don't really find difference, I have worked for long, so I understand the children needs, so you know, where you need to show them the pictures, **we show them the pictures and we got with it symbols**. … or even given them toys. We've got rhymes in symbols.

R: What is your **current method** when you teach?

TA10-M-SP-CH: We are using **sign along**. You know **Makaton one language** in the same time Sign along is sign language.

R: Do you use pictures and cards?

TA10-M-SP-CH: Y**es**, we use picture cards, we use signalong, and we use quda technician, yes different type.

R: What are the **current difficulties** in lesson **which effect on increasing the cognitive load**?

TA10-M-SP-CH: I don't really find any difficulties.

R: Do you use the internet to teach poems?

TA10-M-SP-CH: **We don't use the internet to teach them poems**, we do use the internet in games for children to play.
R: Children package not the poems?
TA10-M-SP-CH: No, not the poems.
R: Do you find teaching poems difficult than other subjects or there is no difference?
TA10-M-SP-CH: I think it's the same; I do poems or rhymes in circle time, they learn by repeating, the poem so this is how they learn.
R: You use it as a tool **for teaching** different things?
TA10-M-SP-CH: **the language**. YES, YES you can say that, yes.
R: How many teaching assistants you have in class?
TA10-M-SP-CH: Ok, we don't have teaching assistants?
R: sorry, the staff, do you feel the staff is enough?
TA10-M-SP-CH: Yes, um.
R: How you can support in lessons like during the task, if somebody doing the task?
TA10-M-SP-CH: The person who is running the activity, either they will tell you can you do that this and this, or you will see if the child can't understand in a circle situation, you sit with them, we got our own picture books.
R: So, you get the **pictures during the session** as well?
TA10-M-SP-CH: We show the pictures from the picture book.
R: Do you always **get well trained staff** even during cover?
TA10-M-SP-CH: **Yes**, staff trained.
R: like training in Makaton, Widgit and sign language?
TA10-M-SP-CH: The staff we all know, use the sign language.
R: but, if you get new staff?
TA10-M-SP-CH: The first thing will happen is given training of sign language.
R: You said you're trained for Makaton. How can lack of attention effect class learning?
TA10-M-SP-CH**: If they can't concentrate much obviously they are not learning** and they are disturbing others as well.
R: Do you find some materials or topics are difficult to explain to the students?
TA10-M-SP-CH: In here we are very simple, you've seen it, they are under age and most of our work is visual, you know even whatever topic we did is **visual.**

R: You don't have any complex topic?

TA10-M-SP-CH: **Yes.**

R: Do you think **finding the right resources, preparing resources** are problems for SEN?

TA10-M-SP-CH: **NO.**

R: Do you **consider the student learning level or his cognitive load when you prepare the material** for them, like you've got different groups?

TA10-M-SP-CH**: Of course**.

R: Do you think **the prototype can support the learning materials**, the students' study and their teaching?

TA10-M-SP-CH: We don't have complex materials.

R: Do you think it can support other **materials like you teach them about their body**, you teach them about **their food maybe you teach them about the gardens**?

TA10-M-SP-CH: W**hatever we are doing is visual**. If we have a **topic about food we got the symbols**, we got the **pictures,** we got **lots and lots of visual support.**

R: How far the lesson **can be adapted to each individual need**?

TA10-M-SP-CH: They always adapted**, all they activity adapted**. The ration is such as we got always 16 children so we know the children and even during one activity we will adapt our language. **Activity according** to that **child needs** or according to that **child's ability.**

R: How the prototype can **focus on individual needs** and how you can **consider for further improvements**, you've seen the prototype, how we can adapt to individual needs, have you got any ideas?

TA10-M-SP-CH: In here the activities are well planned, we change on weekly basis and there are only 16 children so we know the children well and we have a lot of resources.

R: Do you **like the combination choices** here?

TA10-M-SP-CH: On your system?

R: Yes, what you like from your experience, like here I chose information and image. This is for older age. You can put less writing, you can put more writing.

TA10-M-SP-CH: Yes, but I don't know how much**. If I was using it** I might adopted it because we don't really use this kind of teaching, this method of teaching.

R: Do you **like the combination** that I put, in general. I put systems, Information Image, there is combination of text and sound, symbol and text?

TA10-M-SP-CH: **Yes**.

R: Do you have **any suggestions** other than this?

RH: umm **combination of course makes it easier to teach.**

R: You like this combination? you don't like to suggest any other, from your experience?

TA10-M-SP-CH: **It is quite big**, **well spread,** isn't it? **If I was using it, I will find it very comprehensive.**

R: Do you think **the prototype can support teaching assistant**, support the staff?

TA10-M-SP-CH: **Yes**, if they were going to use it, and **obviously its good combination, it's got sound, Makaton there**.

R: Do you think it can **support inexperience assistant**, you got somebody for a cover and don't know the systems, they wanted a poem… [laugh]...or it's difficult they still need to be trained?

TA10-M-SP-CH: I think **training is important**.

R: Do you think **they need less assistant**?

TA10-M-SP-CH: in here our needs are different, but in the classroom, I don't know, I never have worked in that kind of situation.

R: Do you think using text only would be an effective way to teach poems for special needs?

TA10-M-SP-CH: No, it will not be effective.

R: what if it is images only?

TA10-M-SP-CH: Images are more sensible for our children.

R: what if it is only symbols?

TA10-M-SP-CH: It will be again depending on the person who is learning.

R: Can you **describe how the prototype support special needs**; do you have idea?

TA10-M-SP-CH: **I think it can support because what you have showed me is quite nicely done, it can support.**

R: Can you describe how it can **support the teacher or the staff**?

TA10-M-SP-CH: For this system, umm probably as you said **if somebody not trained, this is training to look at it, it's basically training.**

R: Do you think to choose simple, clear, bright colour short poems are more effective for good lesson, more efficient for successful lesson?

TA10-M-SP-CH: Yes, yes, yes.

R: Do you think it may **reduce pressure on teachers**?

TA10-M-SP-CH: Yes, **when you show the symbols, obviously less talking**.

R: Do you think it could **replace or reduce other resources like using cards**?

TA10-M-SP-CH: **No**, I don't think it will reduce. **It is another method.**

R: What about the images, instead of preparing images?

TA10-M-SP-CH: Once the resources is done its done, we are using symbols, we are using cards, we are using sign language.

R: Do you think it may **support other resources** such as props?

TA10-M-SP-CH: **Yes.**

R: Do you think presenting images, symbols or both with text in the same area would be more beneficial for special needs?

TA10-M-SP-CH: We don't really work on words.

R: I mean you put them in the same time or one after the other for your children?

TA10-M-SP-CH: No, no, no we don't show them all in one go because it might cause confusion. The way we work with them is sort of, I can only talk about myself, but very careful when I work with the children so if I am signing and see if my signing is effective for them, I don't want to show pictures in the same time.

R: you like to concentrate on one thing.

TA10-M-SP-CH: at a time.

R: Do you think you would get **better results using the prototype**?

TA10-M-SP-CH: **I think so.**

R: Did **you like the design of the prototype**, the colour, the font?

TA10-M-SP-CH: **Yes**

R: **any changes**

TA10-M-SP-CH: **I think it's good**.

R: Do you think you can **use it in other topics**?

TA10-M-SP-CH: **Yes**, yes, if somebody was using it I can use it in other topics?

R: I mean other than poems, in maths or other teaching topics. Do you think it has **increased motivation** of the students?

R: Do you think using the system would **reduce behaviour problems**?

TA10-M-SP-CH: **not sure**.

R: Do you think you will get better class managements?

TA10-M-SP-CH: Yes, I think so, with more resource. This is a resource.

R: Do you think the prototype can **save preparation time** for teachers and teaching assistants?

TA10-M-SP-CH: If it is already there isn't it, then download, **yes it will save time**.

R: Do you think presenting poems in bold, Italic, different kinds of heading styles would support learning poems for special needs?

TA10-M-SP-CH: Not sure.

R: what type of special needs you think is the **most can benefit from this prototype**?

TA10-M-SP-CH: I think the **people visual impaired**, **bright, inspires looking** and **people with less concentration**.

R: Do you think it is **important to explain at the beginning** of the session how the prototype works?

TA10-M-SP-CH: **Yes.**

R: How much you think the prototype can **enhance special educational needs learning**?

TA10-M-SP-CH: **I can't really say.**

R: What kind of **limitation the prototype has**, do you have any suggestion?

TA10-M-SP-CH: No, Nothing

R: What kind of **improvement suggests improving the prototype**?

TA10-M-SP-CH: **not sure.**

R: You're **happy with the layout**?

TA10-M-SP-CH: **Yes.**

R: Do you think it can **help on improving the education progress** for special needs?

TA10-M-SP-CH**: Yes, I think.**

R: In future would you **choose the prototype**?

TA10-M-SP-CH: **Yes, it might yes.**

R: do you have **any other comment you wanted to add**?

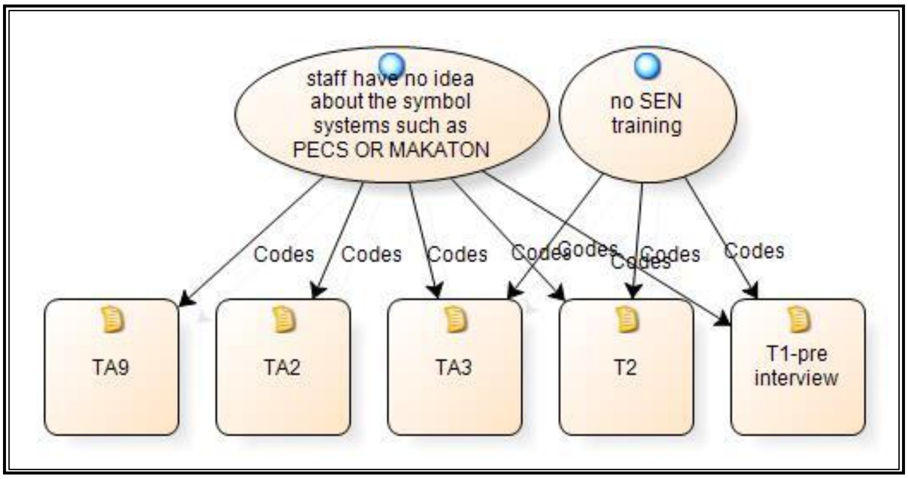
TA10-M-SP-CH: No.

R: Thank you for your time.

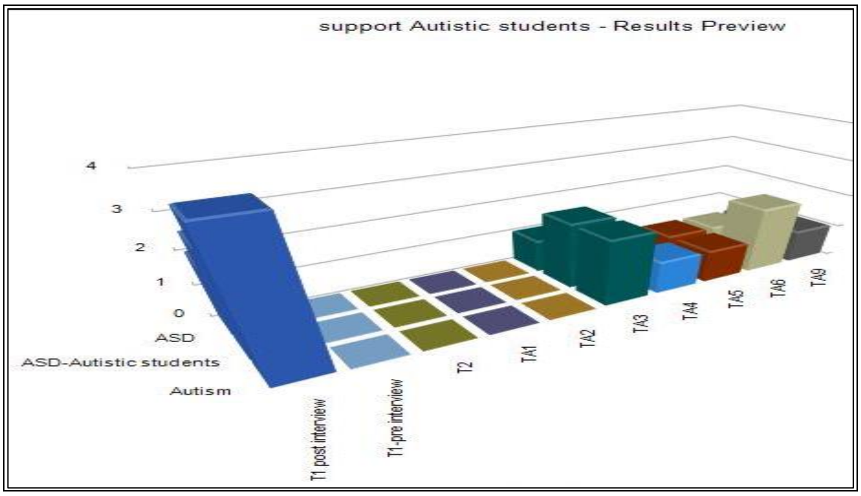
Appendix F: Evidence of the Data Analysis results

a- Pilot Study

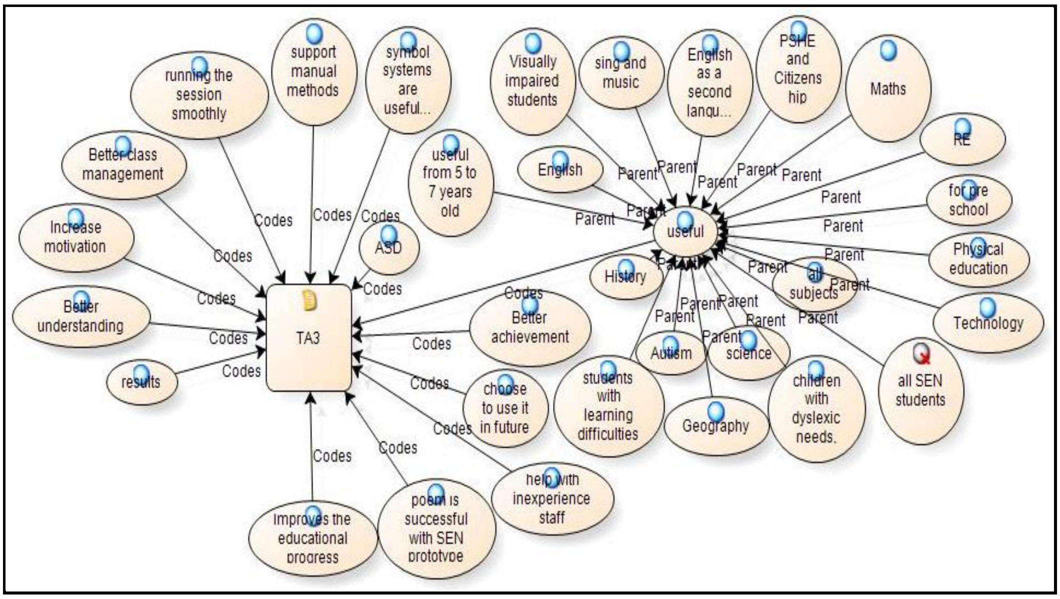
1. The teaching staff current problems with symbols



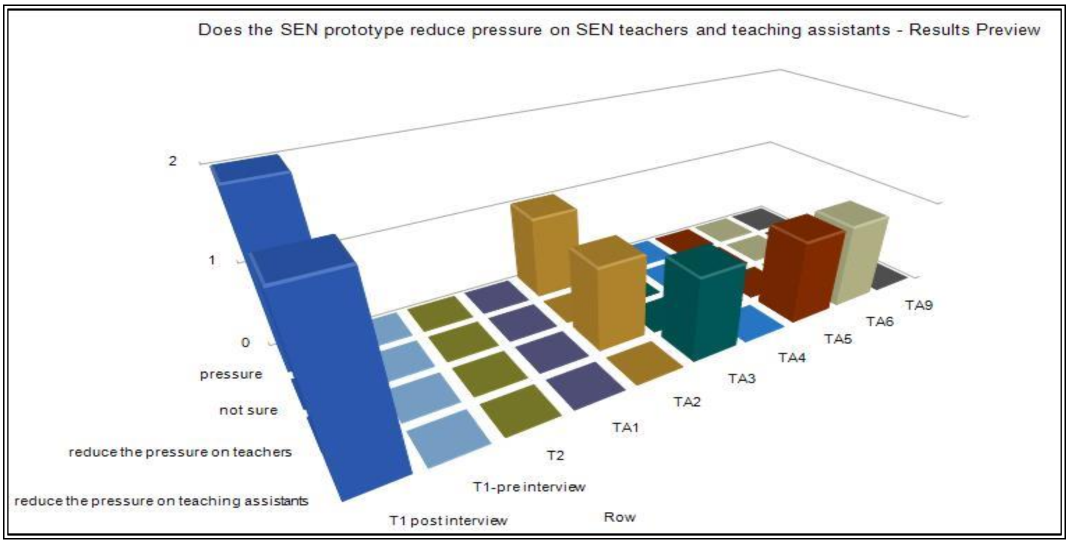
2. SENTP can support the Autistic children



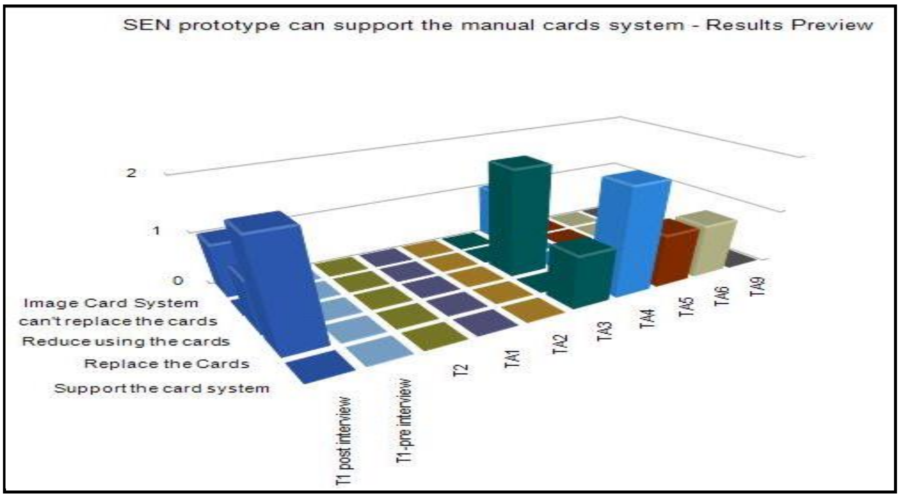
3. Feedback from TA3 Interview



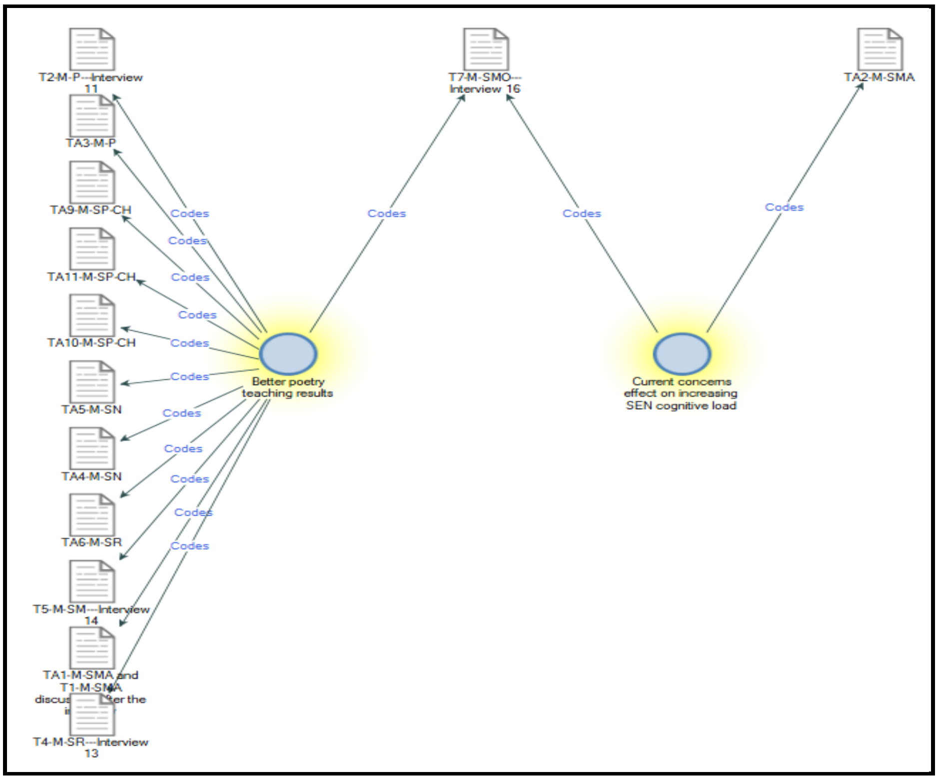
4. SENTP can reduce pressure on the teaching staff



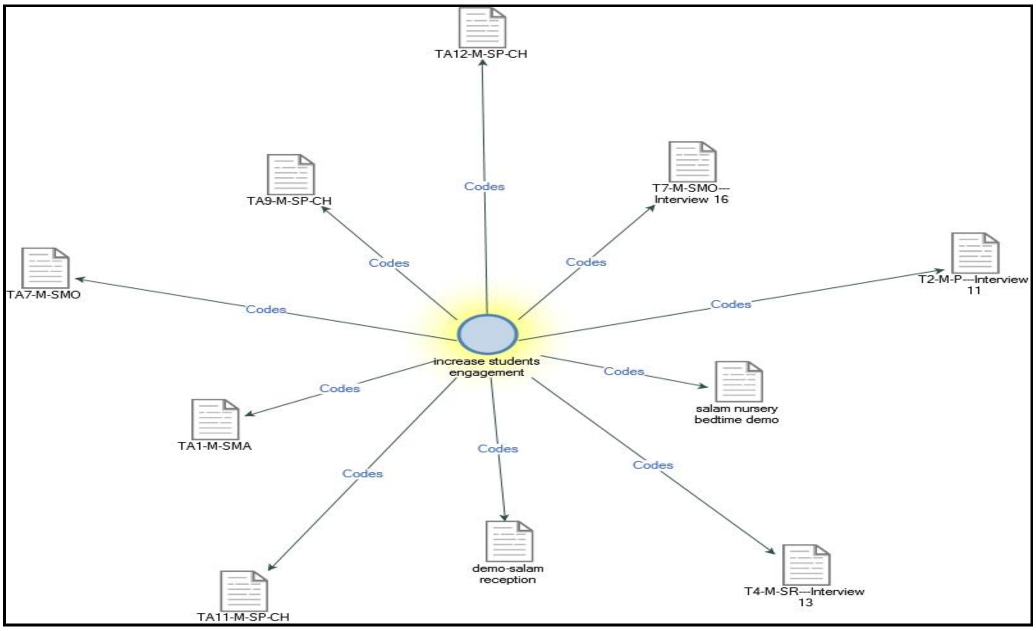
5. Can support card system



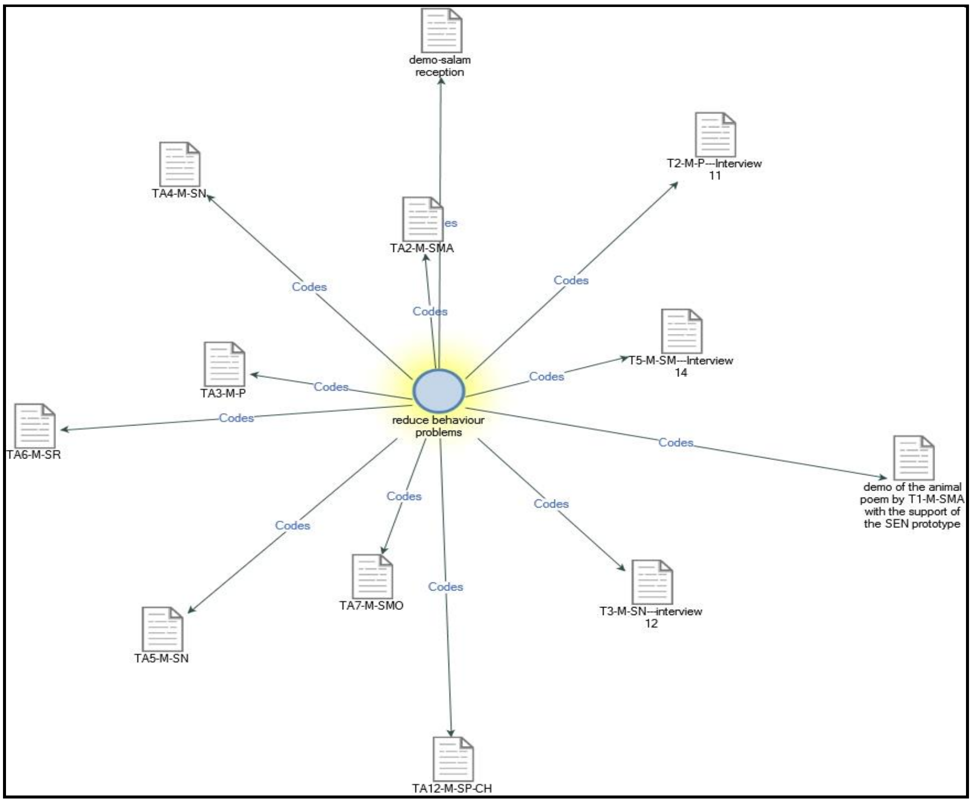
b- Field Testing Annotation



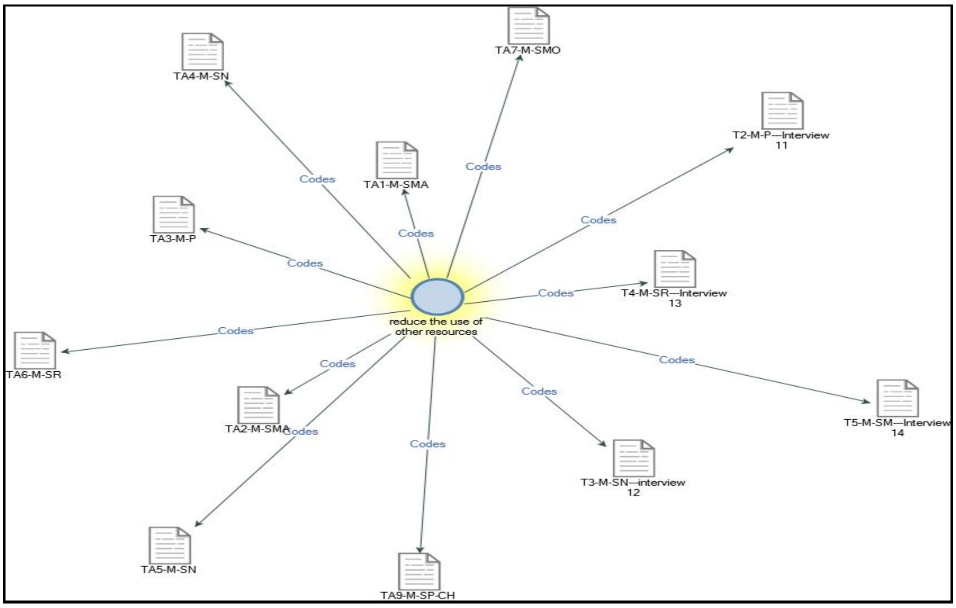
Comparison between the result of using SENTP and the effect of current concerns and cognitive load



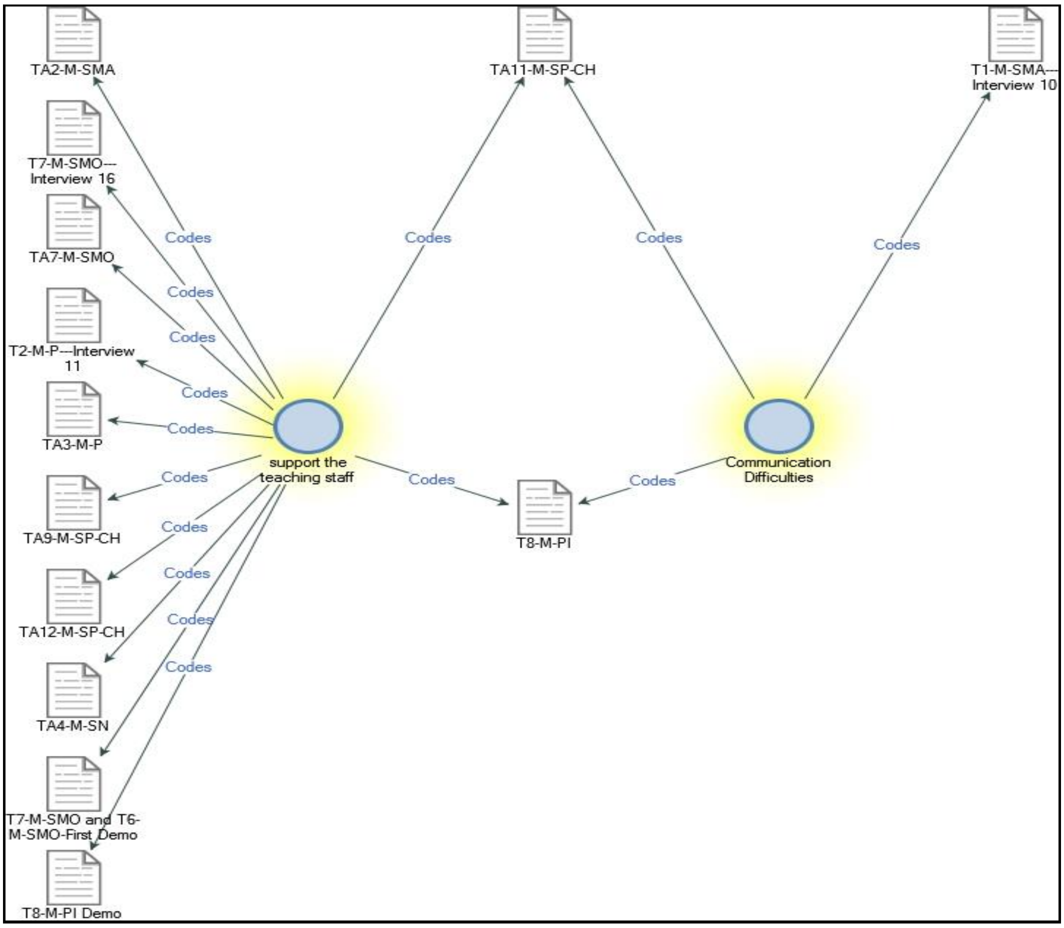
SENTP can increase engagement



Reduce behaviour problems

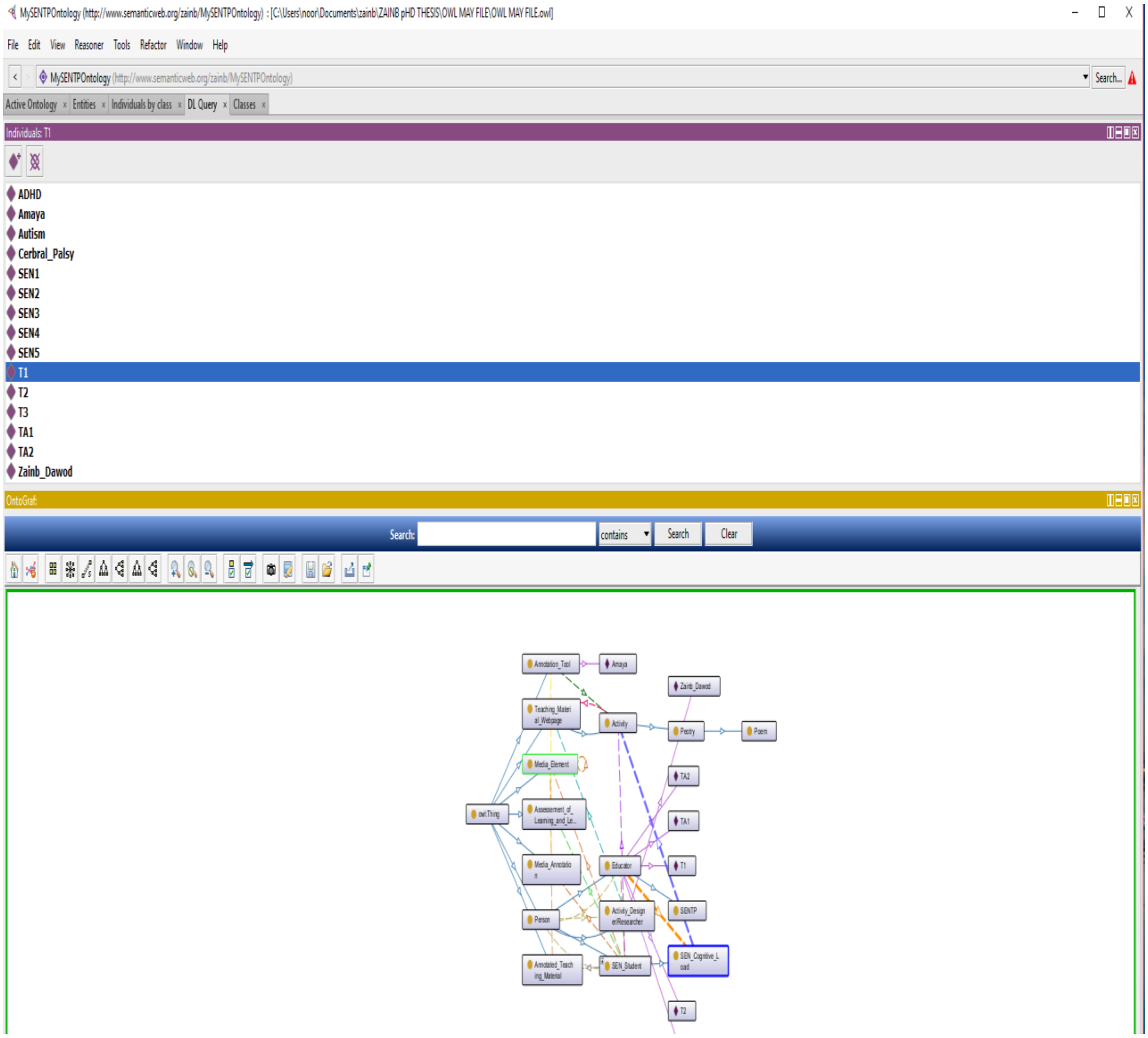


Reduce the use of other resources



SENTP can support the teaching staff compared with the communication difficulties concerns

Appendix G: Evidence of the SENTP Ontology with Protégé 5



All the individuals identified for the purpose of this ontology model