A USER-CENTERED APPROACH TO THE DEVELOPMENT OF A HISTORY DOMAIN ONTOLOGY: HELPING TEACHERS USE DIGITAL PRIMARY SOURCES

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ABSTRACT

MARIA CRISTINA PATTUELLI: A User-Centered Approach to the Development of a History Domain Ontology: Helping teachers use digital primary sources
(Under the direction of Stephanie W. Haas)

The use of primary source materials is recognized as key to supporting inquiry-based history and social studies education. The extensive digitization of library, museum, and other cultural heritage collections represents an important resource for teachers as they strive to develop their students' critical thinking skills. Yet, searching and selecting digital primary sources appropriate for classroom use can be difficult and time-consuming.

This study investigates the design requirements and the potential usefulness of a domain-specific ontology to facilitate access to, and use of, a collection of digital primary source materials developed by the University Library of the University of North Carolina at Chapel Hill (UNC-CH). During a three-phase study an ontology model was designed and evaluated with the involvement of social studies teachers identified as the primary community of end users. The findings revealed that the design of the ontology was appropriate to support the information needs of the teachers and was perceived as a potentially useful tool to enhance access and facilitate inquiry-based instruction. The primary contribution of this dissertation is the introduction of an approach to ontology development that is user-centered and designed to facilitate access to digital cultural heritage materials. This study also contributes to the growing body of literature on teachers' use of digital libraries and primary source materials, especially in the area of social studies education.

A mio padre

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CHAPTER 1

INTRODUCTION

The use of primary source materials, such as letters, diaries, photographs, and other historic documents is recognized as key to supporting inquiry-based history and social studies education. Extensive digitization of library, museum, and other cultural heritage collections has created a tremendous opportunity for fostering new instructional practices. Yet, searching and selecting digital primary sources appropriate for classroom education can be difficult and time-consuming. A domain-ontology to support annotation and retrieval of a digital learning objects collection may facilitate educators' search for primary source materials and their integration into the classroom. This study investigates the design requirements and the potential usefulness of a domain-specific ontology to facilitate access to, and use of, a collection of digital primary source materials developed by the University Library of the University of North Carolina at Chapel Hill (UNC-CH). The study focused on a single digital collection entitled Tobacco Bag Stringing (TBS). The collection describes the lives of individuals and families in the tobacco-growing regions of North Carolina and Virginia involved in the cottage industry of tobacco bag stringing. It is based on a report prepared by the Virginia-Carolina Service Corporation in their effort to lobby against Roosevelt's Fair Labor Standards Act and the minimum wage it required (Stutz, 1939).

1.1. Problem Statement

This study explores whether improving our understanding of how educators search, select, and incorporate digital cultural heritage materials into their teaching practice can assist in the development of domain-specific ontologies designed to facilitate educational access to digital cultural heritage materials.

Ontologies are models of organized knowledge that can help improve the efficiency of information services, including search and retrieval. Ontologies formally define the knowledge of a domain and can be deployed as annotation tools that support rich semantic descriptions of web content. Metadata based on ontologies is given well-defined and explicit semantics that can be computationally processed for more sophisticated functionalities in information retrieval and knowledge management applications. Searches can be performed not only against attribute values, but also against relationships. Subsumption relationships can be used to generalize or specialize a query. Automated reasoning can also be performed through the ontology based on the capabilities of the knowledge representation technique adopted and the functionality of the ontology management system.

An ontology representing the content domain of the TBS collection of learning objects could be employed as an indexing tool to support the annotation of the learning objects with metadata that are semantically richer and may better reflect the information needs of the teachers. The structured and formalized knowledge provided by the ontology could be leveraged in various ways, complementary to content annotation. For example, a full-fledged version of the ontology could potentially be employed for mining the textual content of the learning objects for automatic classification of the objects. In addition, upper categories of the ontology could be translated into components to support concept browsing of the collection and aggregation of search results.

The TBS collection of learning objects represents an ideal testbed for this research study. First, the digitized primary source material covers an important historical period, the Great Depression and the New Deal era, which is both well-suited for a variety of instructional objectives and reflects a manageable segment of the history knowledge domain to be modeled. Second, the UNC-CH University Library staff is interested in and supportive of exploring innovative methods of making their digital collections more accessible to the education community.

Although other categories of educators (e.g., college professors) as well as students of all ages could benefit from the enhancements a domain ontology could provide, the focus of this study is on middle and high school social studies teachers. Informal yet targeted conversations with faculty members from UNC-CH's School of Education revealed that middle and high school social studies educators were a growing educational audience for digital collections of primary sources. They also pointed out that primary sources were an important part of inquiry-based learning, emphasized in current pedagogy and encouraged by school curriculum standards. However, many middle and high school teachers have few opportunities and little time to search and become familiar with digital primary sources or cultural heritage materials.

The lack of tools and services to support school educators in their teaching and learning practices contrasts with the wealth of digital content available to them (Borgman et al., 2005). The critical importance of designing systems, services, and tools based on the actual needs of the end users has been advocated endlessly. Indeed, a paradigm shift from a system-centered to a user-centered approach in system development has been occurring since the mid-1980s (Solomon, 2002). However, technological concerns still take precedence over users' perspectives when designing digital library tools and applications and the "build it and they will come"

approach often prevails. One reason may be the lack of a systematic analysis of users' requirements (Harley, Henke, Lawrence, Miller, & Perciali, 2006).

1.2. Importance of the Study

For over a decade, libraries, museums, and archives have been involved in digitizing and making available rich collections of cultural heritage resources. As mass digitization projects, such as Google Book[1] and the Open Content Alliance[2] exponentially increase the amount of digital content, it is essential to consider how to make the sheer magnitude of such digital content more accessible, more visible, and more usable.

The wide range of uses that cultural digital collections may enable and support, as well as the variety of user communities that may benefit from these collections, make it important to rethink how these materials are discovered, presented, and used. Tailoring digital collections to their intended communities of users is one direction —"customization by community" in Lynch's words (2003, p. 196).

Toward this end, the UNC-CH University Library has developed a series of digital resources tailored to different user communities, particularly the educational community. Education is recognized as one of the most important applications of digital libraries (Fox, 2004) and educators at all levels represent a growing and increasingly essential community of digital library users. Simultaneous with the growth of digital libraries and collections has been the growth of e-learning or "technology-based learning" in which learning materials are delivered electronically to remote learners via a computer network (Zhang, Zhao, Zhou, & Nunamaker, 2004). Across college campuses and K-12 school systems, e-learning has evolved beyond

[1] http://books.google.com/.

[2] http://www.opencontentalliance.org/.

distance education courses to become an integral part of the education process. As a result, academic libraries and cultural institutions are beginning to recognize the need to be responsive and to actively participate in this new learning environment (McLean & Lynch, 2004).

Primary source materials are increasingly valued as educational resources that support effective strategies for inquiry-based teaching and learning (Coventry & Bass, 2003). However, the use of digital libraries for educational purposes represents a serious challenge that developers of digital libraries have just begun to recognize and address (Sumner, Khoo, Recker, & Marlino, 2003). Understanding the needs of educators, how they seek, select, and use digital materials in their instructional context, is seen as a condition for building effective and useful information tools (OCLC E-learning Task Force, 2003).

In an effort to make their digital material more accessible to teachers, the UNC-CH University Library has begun to repackage their digital collections and create a repository of educational materials. One such collection has been derived from a digital collection entitled "Tobacco Bag Stringing" (TBS)[3] based on a report prepared by the Virginia-Carolina Service Corporation in their effort to lobby against Roosevelt's Fair Labor Standards Act and the minimum wage it required (Stutz, 1939). The contents of the report included photographs and rich descriptions of 147 men, women, and families impacted by the New Deal legislation, along with an assortment of letters and other supporting documents. It offers a powerful and unique look at life during the Great Depression in the South and has enormous educational potential. The report was digitized; its component parts separated and cataloged separately so they could be used and reused in different instructional contexts.

The design of the learning objects derived from the TBS collection has been guided by a series of qualitative studies, including individual testing and focus groups, conducted with

[3]http://www.lib.unc.edu/ncc/tbs/.

middle and high school social studies teachers by the University Library staff (Norberg, Vassiliadis, Ferguson, & Smith, 2005). The intention of these studies was to gain feedback on the current use of the University Library's digital collections of primary source materials, as well as to guide efforts to make their cultural heritage materials more useable for their primary users groups, particularly educators. The user studies' findings indicated that teachers find it difficult to efficiently identify and use high-quality digital primary sources appropriate for the classroom. Search and retrieval based on full-text keyword search, as well as on traditional descriptive metadata, often fail to identify aspects of the content that would meet the teachers' instructional needs. Moreover, the process of searching and selecting primary sources for classroom instruction can be difficult and time-consuming.

While repurposing historical digital content in the form of learning objects has the potential to address some of the teachers' concerns (e.g., size of the textual documents, density of content, preference of visual information), how to facilitate the teachers' search and selection process remains an open question.

The UNC-CH University Library user studies identified weaknesses in the capability of metadata and controlled vocabulary associated with the UNC-CH digital historical resources, specifically MARC, Dublin Core, and LCSH, in retrieving images and other materials from the collections (Pattuelli, Norberg, & Smith, 2004). Teachers consistently noted the importance of having geographic access to primary materials, yet the geographic place names used as subject descriptors failed to provide the level of detail they wanted. The limitations of library catalogs in supporting searches by place and the inconsistent levels of precision or granularity of geospatial metadata used by libraries and federal agencies have been confirmed by previous studies (Buckland, 2004; Fraser & Gluck, 1999).

While subject metadata provide broad topical access to the resources, they offer little support for teachers who attempted to put materials into context or to identify meaningful relationships between objects. Other relevant knowledge, such as biographical information, that teachers considered key for active learning, was underrepresented through existing metadata. An equally important need expressed by teachers' was to be able to quickly assess the content of the site. The teachers noted the importance of knowing what was *not* in the collection, as much as what was.

In general, libraries have treated digital materials as they have treated the physical information objects under their stewardship; that is, by cataloging them with metadata standards designed to facilitate traditional search retrieval methods. The limitations of this approach have been particularly confounding for digital cultural heritage materials whose content description does not fall neatly into current bibliographic descriptive practices. Recent efforts have been made to recognize the unique challenges involved in cataloging cultural heritage materials (Baca, Harpring, Lanzi, McRae, & Baird Whiteside, 2006) and to explore the use of semantically enriched and domain-specific metadata to improve discovery and retrieval (Gill, 2004). Moreover, the need to create services and tools that aid teachers' discovery, access, and use of digital resources for educational purposes beyond the support of traditional metadata standards has been highlighted (Qin & Prado, 2004)

1.3. Research Approach

The purpose of this study is to: (1) design a domain ontology representing the TBS collection of learning objects that reflects and addresses the needs and expectations of social studies teachers; (2) evaluate the design appropriateness and the potential usefulness of the ontology from the teacher's perspective.

The underlying assumption is that to develop digital collections of cultural heritage materials that are truly useful in supporting the information needs of their user communities, it is essential to involve the users in the design and development of related services and tools. This is particularly true for the educational use of digital libraries. Friesen (2004) highlights the importance of designers paying increasing attention to existing educational practices, issues of innovation adoption, and heterogeneity of educational activities and contexts when developing e-learning infrastructures. Ontologies are typically constructed by knowledge engineers, with or without the collaboration of domain experts. Excluded from the design process are the real-world end users. In this study, the design of the domain ontology has been informed by user studies and centered on the expressed needs of the educational community which represents the intended audience for the learning object collection. It is believed that the design of a domain ontology could benefit from the input of the intended community of end users and an ontology could be more effective when it incorporates the conceptual framework of its users.

This study addresses the question of whether an ontology has the potential to facilitate the seeking process and the use of primary source materials for classroom instruction. Based on the assumption that an ontology can better serve its functions when it captures the information needs and wants of its intended end users, the two specific research questions the current study addresses are:

1. Is the ontology model appropriate to capture and represent teachers' searching needs?
2. Is the ontology perceived to be useful by the teachers in their seeking process?

To address these questions, the study consisted of three phases.

In Phase I, a set of interviews intended to investigate history and social studies teachers' instructional practices, information needs, and expectations was conducted to gather background information that would help understand whether an ontology would be helpful and what kind of

ontology would be preferred. This phase involved semi-structured interviews with six middle and high school social studies teachers. The interviews were aimed at gathering information on the teachers' perspective on the content domain they address in their teaching and their preferences in terms of access and use of the digital primary sources.

In Phase II, an ontology model was designed to represent a sub-domain of North Carolina History and reflect the subject area of the TBS collection of digital objects. The development methodology included the specification, knowledge acquisition, and conceptualization phases. The outcome of this phase was a model prototype, or *seed ontology*, that was further tested by end users in the third phase.

In Phase III, a user-centered evaluation of the seed ontology was conducted to test the quality of the design of the ontology model and its usefulness as perceived by the intended community of end users.

1.4. Dissertation Outline

This chapter described the motivations behind this research, introduced the specific research questions to be addressed, and illustrated the general approach to addressing these questions.

Chapter 2 of this dissertation reviews the literature relevant to ontologies with a special emphasis on applications to digital education resources as well as the educational use of digital libraries. Chapter 3 outlines the research questions, the significance of the study, and the study design. Chapter 4 describes a set of interviews intended to gather the end users' perspective to guide the ontology. Chapter 5 presents the methodology used to design the ontology. Chapter 6 describes the methodology to evaluate the ontology model. Chapter 7 discusses the results of the evaluation study and how these results address the research questions. Chapter 8 concludes this

dissertation by presenting the research contributions, implications, limitations, and future research directions.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter discusses the research literature related to ontologies and their applications, as well as the use of digital collections in educational settings, to provide a theoretical foundation for the ontology knowledge framework developed and evaluated in this study. The chapter is divided into four sections. The first section of the chapter addresses how ontologies have been described in the literature and their importance for information systems, particularly the web. The second section discusses the use of ontologies in the context of digital libraries, with an emphasis on uses in education. A third section is devoted to discussing literature on learning objects and the descriptive practices for subject access to learning objects, including semantic annotation. The fourth section reviews the literature on users of digital cultural heritage collections, with particular emphasis on middle and high school social studies teachers.

2.2. Ontologies

Ontology is a concept with a long history. As a formal theory, ontology has been at the core of philosophy since Aristotle investigated foundational questions about the nature of being. After crossing centuries of philosophical thinking, more recently ontologies have been adopted in the computer science arena and brought "from academic obscurity into mainstream business and practice on the Web" (McGuinness, 2003, p. 191). In the last few decades, the notion of ontology has been reinterpreted by the artificial intelligence community as an engineering

artifact applied to the core of knowledge-based systems. Artificial Intelligence (AI) was the first non-philosophical discipline to co-opt the concept of ontology. Starting in the 1970s, the field of AI began investigating the potential of ontologies as tools for natural language processing, knowledge engineering, and information integration. Although AI started to provide logical models of the world in the 1950s, only with the advent of expert systems have ontologies and knowledge engineering been recognized as specific areas of investigation (Welty, 2003). This emphasis on ontologies began in the 1990s when ontologies were extensively applied to computer science.

Borrowed by computer scientists, but also investigated in various fields, including Natural Language Processing (NLP), database development, software engineering, and web systems, the term ontology has recently become a popular concept, even a buzzword – widely used, but probably little understood (Welty, 2003). A new array of research activities, mostly focused on practical applications, has transformed the notion of ontology from an abstract philosophical system to an "engineering artifact" (Guarino, 1998a). Most recently the semantic web initiative has recognized ontologies as a key component for addressing the problem of representing machine-processable data to foster more sophisticated web services and applications.

2.2.1. Definitions of Ontologies

The literature contains an overwhelming number of definitions of the notion of "ontology."[4] As Welty (2003) reports, in a non-philosophical context the term ontology was first used by John McCarthy in 1980, but in the mid-1980s the traditional meaning of ontology shifted towards a computer science interpretation of the term. Sowa (1984) viewed "an ontology for a

[4] An overview of ontology definitions, mostly philosophical, is provided by Corazzon (2004).

possible world" as "a catalog of everything that makes up that world, how it's put together, and how it works." The idea of ontology as an "inventory of reality" is close to how Bunge interpreted the notion of ontology, that is, as the "furniture of the world" (1977). A more recent definition of ontology proposed by Sowa (2000) and influenced by Gottfried Leibniz (1646-1716) introduces a further level of complexity and abstraction: "The subject of ontology is the study of the categories of things that exist or may exist in some domain. The product of such a study, called an ontology, is a catalog of the types of things that are assumed to exist in a domain of interest D from the perspective of a person who uses a language L for the purpose of talking about D" (p. 492).

The most widely cited definition of ontology is attributed to Gruber who is also credited with providing the first non-philosophical definition (B. Smith & Welty, 2001). According to Gruber (1993), "ontology is an explicit specialization of a conceptualization" (p. 908). This definition conveys the idea of ontology as a "body of formally represented knowledge" based on a view of the world or universe of discourse that we intend to represent. The view of the world is the conceptualization of that world that may include "objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them" (Genesereth & Nilsson, 1987).

Some sort of conceptualization, either explicit or implicit, is at the core of every knowledge-based system. According to Gruninger and Lee (2002), a conceptualization is "an abstract model of how people think of things in the world, usually restricted to a particular subject area" (p. 40). The conceptualization represented by an ontology is typically explicit and expressed through a declarative formalism (Gruber, 1993). This implies that all the concepts identified by the ontology and the relationships among those concepts are made explicit through formal definitions. This makes the knowledge represented by the ontology computationally

exploitable, sharable, and reusable by agents, either humans or machines. Uschold and Gruninger (1996) provide another widely cited and synthetic definition: “an ontology is a shared understanding of some domain of interest” (p. 5).

Ontologies are considered content theories because they identify specific classes of objects and relations that exist in some domain (Chandrasekaran, Josephson, & Benjamins, 1999). Ontologies may come in various forms, but the common denominator “necessarily include[s] a vocabulary of terms and some specification of their meaning” (Jasper & Uschold, 1999, p.2). The specification of the meaning is intended as the constraint posed on any possible interpretation of the terms and is achieved through the definitions of those terms and their interrelation.

One of the major motivations behind today’s ontology development initiatives is the need to make available mutually agreed upon semantics for knowledge exchange and reuse across software applications. The assumptions and implications of sharing the knowledge of a domain or universe of discourse led to the foundational concept of *ontological commitment* which carries, once again, philosophical connotations (Goldman, 1969; Severens, 1974; Rayo, 2007). In the context of ontology engineering, ontological commitment can be simply explained as an agreement on the use of a shared vocabulary in a coherent way (Gruber & Olsen, 1994). Guarino, Carrara, and Giaretta (1994) interpret the formalization of an ontological commitment in a logical language as the means to specify the “intended meaning” of its vocabulary. Essentially, the ontological commitment can be seen as “a function that links terms of the ontology vocabulary with a conceptualization” (Gomez-Perez, Fernandez-Lopez, & Corcho, 2004, p. 36).

2.2.2. A Taxonomy of Ontologies

The literature presents a proliferation of ontology types that reflects the wide range of different uses and users. This section describes some of the major categories of ontologies as a way to better understand the different roles and applications that ontologies enable and support. A combination of ontology types derived from Guarino (1998a), Studer (1998), and Fensel (2001) provide a rather comprehensive ontology classification that includes commonsense ontologies, top-level ontologies, domain ontologies, (knowledge) representation ontologies, task ontologies, method ontologies, application ontologies, and metadata ontologies.

Commonsense ontologies, also called *general ontologies* (Antoniou & Van Harmelen, 2004) or *common ontologies* (R. Mizoguchi, Vanwelkenhuysen, & Ikeda, 1995), capture general knowledge about the world, including concepts like time, space, events, etc. They are not limited to a specific area and can be used across various domains. An example is the Mereology Ontology (part-of relations) which is applicable in various technical domains (Borst, 1997).

Top-level ontologies, also referred to as *upper-level ontologies*, define general concepts such as space, time, matter, event, etc. and are completely domain-independent. Examples of top-level ontologies are SUMO (Suggested Upper Merged Ontology),[5] the CYC Ontology,[6] MikroKosmos,[7] and SENSUS.[8]

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[5] SUMO has being created by the IEEE Standard Upper Ontology Working Group with the purpose of developing a standard upper ontology that will facilitate "data interoperability, information search and retrieval, automated inferencing, and natural language processing." http://ontology.teknowledge.com/.

[6] The CYC Ontology has been under development by CYCorp. Inc., Texas, since the mid-80s. The goal was to create a general, complete, and formalized ontology of the whole world for making common-sense knowledge machine-processable (Mahesh, 1996). OpenCyc is the open source version of the Cyc technology http://www.opencyc.org/.

[7] MIKROKOSMOS was built at the Computing Research Laboratoty of the New Mexico State University (NMSU) to support interlingual machine translation between different languages (Hovy, 2002). http://crl.nmsu.edu/overviewweb/Kresources/mirkokos.htm.

[8] SENSUS was created by the Information Sciences Institute at the University of Southern California (USC/ISI). An earlier version of it was known as Pangloss, and it was developed primarily in order to support machine translation.

Domain ontologies are focused on modeling specific areas of interest or domains (e.g., medical, tourism, engineering, mechanic, law, etc.). They provide the vocabulary about concepts within a specific domain. The concepts in domain ontologies are typically specializations of concepts already described in top-level ontologies (Gomez-Perez et al., 2004). Examples of domain ontologies include engineering medical ontologies such as GALEN,[9] Gene Ontology,[10] and SNOMED.[11]

(Knowledge) Representation ontologies are not related to any kind of domain and are meant to represent abstract-level entities such as frames, slots, and constraints, as in the case of the Frame Ontology[12] used to support translations between within different knowledge representation languages.

Task ontologies describe the vocabulary related to a generic task or activity (e.g., selling, diagnosing, etc.). They are domain-independent and provide a vocabulary for problem-solving in relation to a specific task (e.g., the Scheduling Task Ontology (R. Mizoguchi et al., 1995)).[13]

Method ontologies model concepts relevant for problem-solving methods (e.g., hypotheses, constraints, and operations).[14]

SENSUS currently contains 90,000 terms and can be accessed using Ontosaurus browser at http://mozart.isi.edu:8003/sensus2/ (Chandrasekaran, Josephson, & Benjamins, 1998).

[9] http://www.openclinical.org/prj_galen.html.

[10] http://www.geneontology.org/.

[11] http://www.snomed.org/.

[12] http://www-sop.inria.fr/acacia/personnel/phmartin/RDF/frameOntology.html.

[13] It is important to clarify that, in *task ontologies,* the term *task* has to be interpreted as "goal type, what needs to be accomplished" without specifying the steps needed to accomplish such goal rather than as a "a set of things to do" (Gomez-Perez, Fernandez-Lopez, & Corcho, 2004).

[14] http://ksi.cpsc.ucalgary.ca/KAW/KAW96/coelho/node5.html.

Application ontologies are the most specific ontologies and describe concepts of a particular domain and task. They are domain-dependent. The concepts defined often correspond to the roles the domain entities play while performing a certain activity.

Metadata ontologies aim to provide vocabularies for describing the content of online information resources. A metadata schema can be considered an ontology in that it specifies the set of physical and conceptual characteristics of resources that have been identified as relevant for a particular community of users. For example, the set of elements (and element refinements) defined in the Dublin Core is itself an ontology in that it provides a representation structure, albeit simple, and a vocabulary, albeit general (Jacob, 2003).

Various perspectives are used for classifying ontologies. Van Heijst et al. (1997) categorize ontologies according to two main dimensions: *types of structure* and *subject of the conceptualization*. According to the *types of structure* classification, three types of ontologies are identified: terminological (e.g., lexicons), information ontologies (e.g., database schemas), and knowledge modeling ontologies. Representation, generic, domain and application ontologies fall under the *subject of the conceptualization* classification.

Guarino (1997a) suggests a classification of ontologies based on the *level of detail* and the *level of dependence* upon a certain point of view or task. *Level of detail* refers to ontologies that are typically very detailed and suitable for establishing or enforcing consensus about a vocabulary. Such ontologies can be also called *reference* ontologies. Typically "sophisticated theories accounting for the meaning of the terms" (p. 143), they require very expressive representation languages. *Level of dependence* refers to simple ontologies (e.g., thesauri) to be employed by users that already share agreement about a conceptual model. These are a type of *shareable* ontologies employed for performing specific tasks such as particular inference services.

Another way to categorize ontologies is to distinguish between *heavy-weight* and *light-weight* (Staab, 2002) ontologies. *Heavy-weight* ontologies provide more restrictions on domain semantics. They support a high degree of formalisms and should include cardinality constraints, axioms for a relational algebra, taxonomy of relationships, and inference mechanisms.

Light-weight ontologies have limited representational expressivity and rigor. They include a small set of primitives: concepts, properties, and relationships structured in *is-a* hierarchies. At this level, we can include a metadata model with its set of concepts and attributes. Such ontologies are also comparable to conceptual database schemas or taxonomies. According to Gruber (2003), ontologies that carry limited semantic rigor, such as lightweight ontologies, can work well for annotation and they are used for mining, but can be more problematic when they evolve in more complex and extended tools.

There are even lighter ontologies, for example the ones that have no relationships between classes. Vocabularies of tags such as "folksonomies" are sometimes thought of as *featherweight* ontologies. By definition they are not based on an agreed upon semantic model and because of that their inclusion into the category of true ontologies can be controversial.

According to Uschold (1996), a common denominator for ontologies is to have a vocabulary where the meaning of the terms is somehow specified. Beyond this requisite, ontologies come in a variety of flavors. For example, based on their degree of formalities Uschold identifies four ontology types: highly informal, semi-informal, semi-formal, and rigorously formal.

Highly informal ontologies are expressed in natural language. According to Gomez-Perez et al., this ontology type is not machine-processable and may not be considered a proper ontology (2004).

Semi-informal ontologies are expressed in a more restricted and structured form of natural language. Terminological ontologies[15] which place limited constraints on relations (*sub-type, super-type* or *part-whole*) and whose concepts and relations are not fully specified by axioms and definitions belong to this type (Sowa, 2000).

Semi-formal ontologies are defined in a formal and artificial language.

Rigorously formal ontologies include logically defined terms, theorems, and proofs of properties. These are *axiomatized ontology,* as defined by Sowa (2000), and are also heavy-weight, as discussed earlier.

2.2.3. Functions and Uses of Ontologies

A clear and comprehensive list of reasons describing why we should develop ontologies is offered by Noy and McGuinness (2001) and includes: "to *share* common understanding of the structure of information among people or software agents; to enable *reuse* of domain knowledge; to make domain assumptions *explicit*; to *separate* domain knowledge from the operational knowledge; to *analyze* domain knowledge."

Uses of ontologies may vary. As Cullot et al. (2003) point out, ontologies can be developed for purely explanatory purposes and serve as a common base for sharing the understanding of some universe of discourse. In this instance, the ontology typically remains uninstantiated and can be deployed to support the design of a database schema. Another use of ontologies is to enable data management services in various ways. Such ontologies are populated

[15] The function of terminological or linguistic ontologies is to describe the semantics of grammatical units (e.g., words or adjectives) rather than provide domain models. They are extensively used in natural language processing. Some of them depend completely on a single language such as WordNet. Others are multilingual, e.g. The Generalized Upper Model (GUM), others are language independent such as Mikrokosmos. They are used for different purposes including online lexical database (WordNet), for machine translation (SENSUS), and natural language generation (GUM) (Hovy, 2002). Terminological ontologies are usually more general and abstract than domain ontologies.

with instances stored in a database or in a web server and they are deployed to facilitate access to data (e.g. by enabling the management of incomplete data).

In their analysis of the importance of ontologies, Chandrasekaran et al. (1999) stress the value of ontological analysis for clarifying the structure of knowledge. Ontology constitutes "the heart of any system of knowledge representation" (p. 21) for a specific domain. Without ontologies there would be no vocabulary for representing knowledge and no practical way to share knowledge. As pointed out by Pisanelli, Gangemi, and Steve (2002), the positive role ontologies can play in building information systems and facilitating interoperability is widely recognized. The increasing need to unambiguously communicate and share data among different communities in relation to different tasks can benefit from a rigorous and task-independent conceptual analysis, as advocated by Hayes (1985b) since the mid-1980s (Vickery, 1997).

The role of ontologies in enhancing the knowledge communication process is highlighted by Studer, Benjamins, and Fensel (1998) who describe ontologies as "models of the world" which provide a conceptual basis for communicating knowledge. Along the same line of thinking, Noy and McGuinness (2001) assert that "an ontology defines a common vocabulary for researchers who need to share information in a domain" (p.1).

Vickery (1997) lists various uses of ontologies in knowledge engineering that pre-date the semantic web. Traditionally, ontologies have been exploited by computer programs for various purposes, including classification, inductive reasoning, and problem solving besides the function of supporting information exchange between systems. Ontologies are employed for database merging and integration of models of the same domain in natural language processing; in this case, ontologies are used "to provide grounding for representing text meaning in an interlingua" (p. 284). They also facilitate knowledge sharing among multilingual lexicons and support semantic disambiguation.

2.2.4. Web Ontologies

More recently, ontologies have become a popular research topic within the web development community in a broad range of fields. The advent of the web has given new impetus to the research on ontologies among various communities, including knowledge engineering, databases, and software engineering (Gomez-Perez et al., 2004). Web developers have diminished the arcane allure ontologies used to have and started to handle ontologies as more tangible entities. In fact, ontologies can be seen simply as files that formally define relations among terms and are identified and referenced by URIs (Berners-Lee, Hendler, & Lassila, 2001). As a mechanism capable of improving the use of the web, ontologies are a critical component in knowledge management and an effective modeling structure for other application areas such as e-commerce. Considered a foundational technology and a central component of the infrastructure needed to enable the semantic web (Berners-Lee, 1999), a remarkable and constantly growing amount of research on ontologies is being produced by the semantic web community.

The main streams of ontology applications follow the directions of academic research[16] and e-commerce. Web developers are increasingly recognizing the central role ontologies may play in improving web information description, extraction, and retrieval. Ontologies applied at the backend of web-based infrastructure are able to support information architectures of various degrees of sophistication. For instance, an ontology underlying online directories such as Yahoo! provides a navigation device which helps users to browse structured topics of interest (Labrou & Finin, 1999). According to McGuinness (2003), ontologies are already being used in various online applications, including search services (Yahoo!, Lycos), e-commerce (eBay, Amazon), and configuration (Dell, PC-Order).

[16] Overviews of major ontology research initiatives are available at http://www.cs.utexas.edu/users/mfkb/related.html and http://www.ontoportal.org.uk/related.html.

Another application of web ontologies is to support indexing services for search engines. Both the academic and commercial communities are involved in developing tools for automatic and semi-automatic metadata extraction and annotation which are ontology-driven (Handschuh & Staab, 2003; Handschuh, Staab, & Maedche, 2001; Motta et al., 2002; Stuckenschmidt & van Harmelen, 2001). Another functionality ontologies enable is "intelligent" access to web resources using semantic queries or dynamic hypertext views (Fensel, Hendler, Lieberman, & Wahlster, 2003).

The potential of ontologies to support information exchange, integration, and translation has been extensively explored for knowledge management, electronic business and web commerce applications and transaction services (Fensel, 2001). The capability to reconcile the heterogeneity of database information makes ontologies a promising tool for improving data integration from multiple applications and semantic interoperability. Extensive research in this direction has been developed by Sheth and Ramankrishnan (2003) who advocate the centrality of ontologies to address the issue of semantic integration in database management. Areas such as electronic business ontologies have been explored extensively for harnessing heterogeneous databases (Hunter, 2000).

The potential of the impact of ontologies on web applications has been compared to that of programming languages in the 1970s and 1980s (Fensel, 2001). The semantic web community, made up of researchers from academia, government, and industry is playing a leading role in ontology research activities and represents a dynamic area of current Internet development (Hendler, 2002). The semantic web project emerged from Tim Berners-Lee's vision: "Leaving aside the artificial intelligence problem of training machines to behave like people, the semantic web approach instead develops languages for expressing information in a machine processable form" (Berners-Lee, 1998). The semantic web initiative works on the idea

that adding machine-processable semantics to web-based information will improve the web's functionality (Berners-Lee et al., 2001). By having meanings associated with structured data that better describe information content, search engines of the future will be able to understand context and evaluate the quality of resources. Also, using "intelligent" software agents as mediators between users and information resources, the semantic web intends to provide the basis for a wide array of new distributed knowledge-based applications. Sharable formalized vocabularies, powerful reasoning services, and trusted information mechanisms are at the core of the semantic web infrastructure and ontologies have been considered the "keystone" for spinning the evolution of the web "from a document repository to a knowledge base" (Brickley, Guha, Lassila, & Miller, 1998).

To date, the semantic web has not met the expectations of its initial vision. Semantic web applications have not reached any critical mass and its full realization may never come to light, at least in the form originally envisioned. Hendler (2004), one of the founding fathers of the semantic web, has pointed out some of the challenges that the semantic web faces. For example, the open nature of the web poses serious limits to the capability of reasoning mechanisms if compared to the standards of traditional AI. Linking ontologies together and using terms from one another in a distributed and uncontrolled environment inevitably produces inconsistencies. Addressing inconsistencies with more forgiving applications is seen as a more viable solution rather than trying to avoid or resolve them. This approach reflected in Hendler's (2004) slogan "a little semantics goes a long way"[17] is now widely adopted in the semantic web community.

The future, potential, and chances of realization of the semantic web are hotly debated topics across the blogsphere. Semantic web standards and ontology tools continue to be in

[17] http://www.daml.org/committee/minutes/2001-07-03.html.

development. Most are still in the form of prototypes, but some have successfully colonized the web (e.g., RSS[18]).

The broad range of applications and benefits that ontologies offer needs to be considered in light of the technical challenges that the development of such tools poses. Web ontology engineering is still a rather novel and complex activity. The grand vision of the semantic web has largely contributed to the rapid increase of interest on ontologies and the proliferation of initiatives and projects that have ontologies at their core. More ontology development tools are becoming available for a new crop of developers and established tools such as Protégé[19] are being continuously updated to accommodate the rapid pace of an evolving scenario. The literature describing the potential of using ontologies and semantic web technologies is proliferating and may give the impression that ontology-driven systems are close at hand.

2.2.5. Semantic Annotation

Metadata can be used to annotate entities of any kind and size, from documents to applications. They can serve different functions, including descriptive, structural, and administrative. The purpose of metadata is to improve information seeking and retrieval, and also information understanding and use.

Semantic metadata have emerged from the semantic web initiative. Semantic metadata are ontology-based in that they are created using ontologies as their vocabularies (Corcho, 2006). As a knowledge representation tool, the ontology offers a conceptual foundation for formally defining the meaning of the metadata terms for semantic markup of the digital resources. The

[18] RSS is a family of web feed formats used to publish frequently updated digital content. RSS was initially developed as an RDF application before multiplying in numerous languages.

[19] Protégé is an ontology editor and knowledge-base framework developed at Stanford University http://protege.stanford.edu/.

notion of semantically enriched or deep annotation is at the foundation of the semantic web (Handschuh, Staab, & Volz, 2003). As Mizoguchi (2003) describes, "metadata used in semantic web is built on the basis of an ontology which constrains and partially defines the meaning of each tags and values [sic]. Interpretation and translation of the metadata can be done via ontologies. Ontologies thus play the role of glue which guarantees semantic interoperability among metadata" (p. 375).

In the area of digital libraries, ontology-driven annotations offer significant advantages to subject access to resources over traditional bibliographic descriptions. As Slavic (2003) notes, the importance of subject access to web resources has been often stressed (Koch & Day, 1997; Kwaśnik, 1999; Hodge, 2000), but the educational domain represents a specific area where subject access can be particularly important.

The limitations of subject access to online library catalogs have been analyzed in past studies (Sridhar, 2004). One of the major factors that reduce effectiveness in the use of subject search is the difficulties users find in formulating subject queries based on the Library of Congress Subject Headings (LCSH) (Larson, 1999). Indeed, the terminology provided by subject headings can be very remote from the vocabulary of the user.

Many scholars have identified the need to adapt existing subject cataloging practices to a completely new information environment such as the web. Chan and Hodges (2000) argue that LCSH should be modified to achieve: "simplicity, interoperability and scalability" (p. 229). Specifically, the syntax needs to be simplified by separating the terminology from the syntax; LCSH should become more faceted and post-coordinate in order to be compatible with mapping to other vocabularies. The necessity to develop alternative subject access tools to overcome the limitations of the traditional subject searching as conceived and enabled by traditional subject cataloging practice has long been advocated (Lancaster, Connell, Bishop, & McCowan, 1991).

Fischer (2005) proposes an updated critical bibliography on LCSH that spans the decade 1990-2001. A number of the drawbacks and cultural biases of LCSH are addressed. For example, intrinsic racial connotation of African American subject descriptors are described (Nuckolls, 1994, p. 243). Inconsistencies and irregularities are among the limitations of LCSH (Chan & Hodges, 2000). The lack of specificity of terminology in subject areas was another issue described by Fischer (2005) as a major obstacle for mapping LCSH to other controlled vocabularies, such as the Art and Architecture Thesaurus (AAT). As libraries change and adapt to the new information environment, the question of whether or not LCHS will remain the primary tool for subject access is under debate. As Calhoun (2006) points out, the nature of the library catalog is shifting and needs to be integrated in a broader set of discovery tools. The risk for libraries to be marginalized for relying exclusively on the catalog for resource access has also been discussed (Coyle & Hillmann, 2007). A report from the University of California Bibliographic Services Task Force (2005) seemed to agree: "For the past 10 years online searching has become simpler and more effective everywhere, except in library catalogs" (p. 11).

New models of content description have emerged in the online information environment to address subject access to information. Web-based descriptive systems such as Dublin Core, Encoded Archival Description (EAD), Text Encoding Initiative (TEI), and Visual Resources Association (VRA) Core have been developed over the last decade and are now part of a sandbox of tools for digital libraries. However, there is still enormous need for effective subject access (Fischer, 2005). One increasingly significant example is social tagging. This "bottom-up" or user-centered approach to the subject classification of information subverts more traditional models used by libraries and other organizations.

Semantic annotation is another method digital libraries could explore for content description that offers enhanced functionality and facilitates data interoperability and exchange.

In fact, the semantic web is based on the notion of "common formats for integration and combination of data drawn from diverse sources, whereon the original web mainly concentrated on the interchange of documents."[20]

A major purpose of semantic annotations is to improve information access by supporting concept-based retrieval. While traditional metadata are recognized syntactically by machines and the retrieval is based on the matching of data string tags, semantic metadata, which are formally and explicitly specified by the ontology, enable information retrieval at the conceptual level. This implies that user queries are mapped onto the conceptual structure of the ontology and searches can be performed not only against attribute values, but also against relations.

Research has shown that having metadata based on ontologies can be beneficial. In a study addressing ontology-based metadata, Weinstein (1998) converted a bibliographic catalog encoded in MARC format into a knowledge base realized by rooting metadata in an ontology. The logical foundation of ontology-based metadata showed empowerment of the existing bibliographic relationships and support for more accurate queries. In a comparison between ontologies and bibliographic description systems, Weinstein and Alloway (1997) identified characteristics that show that ontologies are more expressive because each term is defined in relation to other terms in a complex web of meaning. Ontologies are also more precise due to the computational power of logic.

2.2.6. Ontologies and Education

While the contribution ontologies can make to the design and implementation of information systems in areas such as bioinformatics, genomics, and agriculture is widely recognized, the application of ontologies to digital libraries is still limited. Digital libraries are

[20] http://www.w3.org/2001/sw/.

just beginning to pay attention to ontologies as a means to represent the semantics of documents to help organize, index, and search digital resources (Sure & Studer, 2005).

In the field of education, the role ontologies could play is also just beginning to be considered. As a JISC[21] report indicates:

> searching for material that supports educational requirements can be a matter of trial and error. It is not that humans are putting in the wrong search terms, but that machines are unable to interpret ontological relationships between those terms. In other words, it will have difficulty bringing together material which is related by defining characteristics (Wilson, 2004).

In this report, that examines the role of ontologies in teaching and learning, Wilson (2004) notes that ontologies have the potential to provide the technology that can semantically link resources related by subject matter, thus enabling searching and aggregating information based on the content of the objects. This would offer the possibility of accessing information seamlessly, regardless of the format or media type. This could represent a tremendous benefit to educators in their resource selection process.

There is a growing interest in the use of ontologies and semantic web technologies to support e-learning systems (Brase & Nejdl, 2004; Sampson, Lytras, Wagner, & Diaz, 2004; Aroyo & Dicheva, 2004; Stojanovic, Staab, & Studer, 2001). The semantic web community is currently positioning itself in the forefront of research into technical solutions for e-learning that are able to handle the complexity of learning and teaching environments. "Semantic e-learning" is a neologism coined to refer to a new field of theory and practice. A 2006 issue of *The British Journal of Educational Technology* was dedicated to the "advances of the semantic web for e-learning" (Naeve, Lytras, Nejdl, Balacheff, & Harding, 2006, p. 321).

In the context of education, major research efforts are dedicated to the application of ontologies to scholarly communication (Uren, Buckingham Shum, Li, & Bachler, 2004),

[21] Joint Information Systems Committee (JISC), http://www.jisc.ac.uk/.

management of courseware resources (Tane, Schmitz, & Stumme, 2003), and adaptive educational hypermedia (De Bra, Aroyo, & Chepegin, 2004). Research studies have also begun to address the use of ontologies in relation to learning objects.

2.3. Learning Objects and Ontologies

2.3.1. Learning Objects

"Learning objects have recently become a popular resource for e-learning and web-based teaching" (Wiley, 2000). Because of their emphasis on reusability, learning objects offer a solution to the exponential increase in educational information available and the parallel decrease in investment in educational technology support (Metros & Bennett, 2004). The literature provides different definitions for the concept of learning objects, also called information, educational, or knowledge objects, which reflect the interpretations of the various communities (computer scientists, educators, commercial publishing houses, and libraries) involved in their development. While instructional designers tend to see learning objects primarily as reusable "chunks" of digital content, computer scientists consider learning objects more as containers of content and instructional components of learning management systems based on object-oriented programming.

The most "official" definition of what a learning object is comes from the IEEE Learning Technology Standards Committee (IEEE LTSC): "[A learning object is] any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (IEEE Learning Technology Standards Committee, 2002). Such an open definition implies that learning objects may come in a wide range of shapes and sizes, as well as complexity of structure and density of content. They can be in the form of pre-arranged packages of content, such as

those often found in the education publishing industry, or they can be small units aggregated dynamically as the result of RSS-driven processes as envisioned by e-learning pioneer Stephen Downes (2004). As Wiley (2003a) argues, there are two "orthogonal paths" in instructional technology related to learning objects that embrace two colliding instructional philosophies. On the one hand, there is the automated instruction approach that does not include the mediation of an instructor. On the other hand, there is the social constructivist approach that tends to include more and more humans in the instructional context through various participatory applications, including wikis and blogs.

The multiplicity of interpretations of what a learning object is implies a broad array of options for designing the objects but offers no indications of what characteristics make learning objects effective in teaching practice. This ambiguity is seen as one of the reasons why this promising educational technology has not yet met expectations in terms of impact on teaching practice and rapid adoption by educators (Metros, 2005).

To facilitate the access and use of digital primary sources for the education community, the UNC-CH University Library has decided to repurpose portions of digitized historical content from its collections in the form of learning objects. In an attempt to better meet the instructional needs of history and social studies teachers, the design of the learning objects has been guided by the findings from user tests and focus groups conducted by the Library staff with educators over the last few years (Norberg et al., 2005).

The resulting learning objects diverge from the more common notion of a learning object as conceived and applied by computer scientists and instructional technology companies that requires little if any role for the human instructor. The UNC-CH University Library learning objects are primarily intended as instructional building blocks for "mediated" or "instructor-led learning" and are intended to be purposed and repurposed by teachers for a variety of

instructional objectives. Such an approach is not only supported by the findings of the UNC-CH Library user studies, but it is also endorsed by relevant literature that emphasizes the value of social interaction as a necessary condition for effective learning. As Artacho asserts, "Learning is a process between teachers and students, and teachers tend to have their own view of learning and the way they use learning materials in class" (van Kasteren, 2003, p. 13).

Criticism is increasingly emerging about the capability of "learning objects standards and recent learning design approaches to effectively manage the requirements for active pedagogy in learning contexts" (Lytras & Naeve, 2006, p. 484). More research to deepen the understanding of "learning principles and articulated pedagogies" embraced by learning objects is needed (Metros & Bennett, 2004, p.3). Metros and Bennett further stress the importance of analyzing existing educational practices, aspects of innovation adoption, and the educational context in general for developing effective models for learning objects.

There is a growing body of research addressing the issue of contextualization or customization of learning objects for specific audiences or learning objectives (Phillips, Hawkins, Lunsford, & Sinclair-Pearson, 2004; Razmerita, Gouardères, & Conté, 2005; Weihong Huang, Webster, Wood, & Ishaya, 2006). The trade-off between contextualization and reusability is hotly debated within the learning object community and there is a need to find management solutions that enable both dimensions (Wiley, 2003b). Learning objects that are highly contextualized can serve specific audiences and/or learning objectives quite well, but their reuse for other audiences or other objectives may be limited. On the other hand, if a learning object is not contextualized, it may not serve educators who have limited time to provide the necessary customization.

Organizations such as the IMS Global Learning Consortium (IMS)[22] and the IEEE[23] have

[22] http://www.imsglobal.org/.

developed learning object metadata standards to provide a context for educational resources. IMS (2001) and IEEE Learning Object Metadata (IEEE LOM)[24] are major educational metadata schemas that describe resources primarily from the point of view of their role in the pedagogical context and their place in the curriculum. As Sosteric and Hesemeier (2002) point out, educational metadata standards help to provide the infrastructure for contextualizing learning objects, a role that in the past was played directly by instructors.

By and large, much of the research conducted on the application of semantic web technologies to learning objects has focused on management issues involving reusability and contextualization. For example, ontologies have been designed to enable the aggregation and sequencing of learning object content on the basis of pedagogical objectives and learning tasks (Mohan & Brooks, 2003; Qin & Finneran, 2002; Gašević, Jovanović, & Devedžić, 2004). Another possible way to add context to learning objects without limiting their usability and re-usability is through the semantic annotation of their content. The use of semantic metadata has the potential to enable search, aggregation, and navigation functionality that better serve the information-seeking needs of the community of educators and learners.

2.3.2. The Challenges of Ontology Development for Learning Objects

As the literature shows, ontologies and ontology-driven metadata have the potential to significantly enhance information systems, including digital libraries and educational applications such as learning objects. However, ontologies are a rather novel tool in the context of the web and digital libraries. Despite the large corpus of ongoing research on ontologies,

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[23] http://ltsc.ieee.org/.

[24] IEEE 1484 Learning Objects Metadata (IEEE LOM), available at http://ltsc.ieee.org/wg12/.

primarily as the key infrastructure to enable the semantic web, real-scale applications are still limited. The number of ontologies developed in a wide range of domains is rapidly increasing, but few have left the research labs (Hepp, 2007). The technical and economic challenges associated with the development and deployment of a domain ontology are far from trivial. The cost benefits of ontology development are not yet known (Bontas & Mochol, 2006) and as Ding and Foo (2002) point out, "manually constructed ontologies are time-consuming, labor-intensive and error-prone" (p.123). Critical issues of scalability, interoperability and adaptability are also part of the ongoing debate.

There is a clear need for more evaluation studies to assess the practical effectiveness and usefulness of semantic web tools and applications, including ontologies. One of the underlying questions addressed in this study is whether or not developing and deploying a domain ontology for a collection of learning objects is, simply stated, worth it. One way to assess the usefulness of such a tool is to maximize the development process by understanding and involving the end users.

2.4. The Users: Teachers and Digital Libraries

The importance of understanding the user's perspective when designing new library services or tools has been stressed (Harley et al., 2006). Toward this end, the design of the ontology developed for the TBS learning object collection has been centered on its primary community of end users represented by middle and high school social studies teachers. A review of the literature on this targeted population of end users provides a broad frame of reference for the first phase of this study. It also offers important information to understand the context, the practices, and the needs of educators using digital libraries for teaching and learning. The knowledge derived from the literature has served to inform the construction of the interview

protocol and contextualize the data collected from the interviews. Areas addressed in this review include the use of technology in the classroom, digital libraries in both general and historical education, and the instructional use of primary sources.

2.4.1. Technology in the Classroom

The potential of technology to impact teaching and learning is universally recognized. However, technology is still far from being fully exploited in instructional contexts (NetDay, 2001; Bebell, Russell, & O'Dwyer, 2004). The presence of technology in the classroom in public schools is widespread and 99% of public school teachers have access to computers (Rowand, 2000). In their overview of the use of technology in teaching and learning, Lara and Whittier (2004) found that the federal investment during the second half of the 1990s essentially achieved its goal of making computers and Internet connections available in the majority of public schools.[25]

Despite the ubiquity of information technology in the schools, educators have failed to incorporate it fully into their teaching. When it has been adopted and used, it has been used in ways that did not substantially change their traditional instructional practices. Research conducted by Cuban (2001) on the effectiveness of technology in schools revealed that the impact of technology on student learning is highly dependent upon how it is used in the classroom. Findings from a study of Silicon Valley schools revealed that less than 10% of teachers used their classroom computers at least once a week and less than 5% integrated computer technology into their instructional practices. The majority of teachers typically

[25] In 2005, close to 100% of the public schools reporting had access to the Internet (http://nces.ed.gov/fastfacts/display.asp?id=46).

employed computers for traditional teaching tasks rarely going beyond the use of word processing and Internet searches. Findings from *The National Center for Education Statistics (NCES) 2000–01 Teacher Follow-up Survey* reinforced this theme by revealing that classroom access to the Internet and e-mail capability are considered by teachers the two most important technologies to support instruction (Lanahan & Boysen, 2005). The latest CEO Forum on Education and Technology also showed that the introduction of new technology into the classroom has neither modified the traditional pedagogical methods nor met the promises of more active and student-centered teaching methodologies (CEO Forum on Education and Technology, 2001). In Cuban's opinion, "computers have been oversold and underused, at least for now" (p. 197) and the educational revolution that computers were expected to trigger has progressed slowly. Lack of hardware and software infrastructures, scarcity of funds and teachers' technophobia are only part of the problem. Although a huge amount of federal funds has been invested in technology for the classroom over the past decade,[26] these efforts have not produced a significant impact on education. Cuban (2001) believes that real change will only occur with a strong commitment to public education that goes beyond merely preparing for a professional future; it will require a "broader vision of the social and civic role that schools perform in a democratic society" (p. 197).

Factors preventing teachers from harnessing the full potential of technology by integrating it into their teaching practices varied. One NetDay survey identified teachers' lack of time as the main reason, while scarcity of equipment, technical support, and speed of access represented secondary barriers (NetDay, 2001). Still, the presence of technology is only part of the solution. Several researchers have also noted that teachers need adequate training,

[26] The project *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge* (U.S. Department of Education, 1996) conducted from 1996 to 2000 was funded with two billion dollars.

professional development, and a positive attitude in order to truly make effective use of technology in their teaching practice (Ringstaff & Kelley, 2002; Dooley, Metcalf, & Martinez, 1999; Vannatta & Fordham, 2004; Kadel, 2005). Similarly, a study conducted in rural Texas revealed that "higher users of technology had a more favorable attitude toward change, were more able to cope with uncertainty and risk, less fatalistic, and had higher levels of motivation, more social participation, and greater exposure to communication channels" (Dooley, Metcalf, & Martinez, 1999, p. 10). Cuban (2001) argues that, in order to make educational technology effective in the long-term, it is necessary not only to reshape the current educational model but to include teachers in administrative decisions about technology implementations. While instructional technologies are growing at a rapid pace, investigations of the attitudes of educators as well as learners towards the new educational environment are still scarce (Liaw, Huang, & Chen, in press).

The use of role models or mentors has become a popular and effective approach used by school administrators to encourage the use of technology. Several studies report the success of apprenticeship or mentoring programs that are integrated into the day-to-day practice of teachers over training seminars that take place outside of the schools (Bell, 2006; Demetriadis et al., 2003; Glazer, Hannafin, & Song, 2005; Margerum-Leys & Marx, 2004). An innovative program in the Olympia School District in Washington, GenYES, actually used tech-savvy students to help teachers overcome their resistance to technology (Chuang & Thompson, 2006).

2.4.2. Digital Libraries in Education

The educational community represents one of the key audiences for digital libraries (Fox, 2004). "Digital libraries have become a core ingredient, a collective memory of the educational environment of today and of the future and they have the potential for transforming teaching and

learning by providing supporting resources, tools, and services and provide a virtual learning environment open to new technologies" (Kalinichenko, 2003, p. 57). Educators at all levels represent a growing and increasingly important community of digital library users. The need for digital libraries to become more user-centered to better support the educational tasks and activities of students and teachers is widely recognized. As an important provider of digital libraries, the library community has become increasingly aware of the need to understand how educators identify and use digital materials in the classroom (OCLC E-learning Task Force, 2003, p. 11). Gaining a better understanding of how educators seek, select, and use digital materials in their instructional context is viewed as critical for building effective and useful digital information tools.

Studies of online information seeking behavior in education constitute an impressive body of research. Sumner et al. (2003) and Sumner and Marlino (2004) have addressed the implications of educators' behavior in relation to the interface design of digital libraries. However, as Hart (1998) points out, initial studies were devoted to the physical sciences. Borgman et al., for example, have done extensive work on the information seeking process of geography professors and their use of the Alexandria Digital Earth Prototype (ADEPT) project (Borgman et al., 2000; Borgman et al., 2004; Borgman et al., 2005). The researchers looked at how faculty members use digital materials in their teaching as opposed to their research. Their research indicates faculty members prefer to search by concept as well as geographic location.

Another prominent area of research in science education is that surrounding the National Science Digital Library (NSDL). The NSDL provides access to collections of science, technology, engineering, and mathematics (STEM) educational resources and services.[27] The development of system requirements to support interoperability and reuse of educational content

[27] http://nsdl.org/.

for different applications has been at the center of the NSDL's program. Nevertheless, as Recker et al. (2004) point out, little attention has been devoted to understanding the characteristics of learning environments and the role digital learning resources could play in these environments. Broad availability and open access to educational materials, even on a large scale, does not necessarily translate into easy access and effective use and integration of these materials into instructional practice (Recker et al., 2005).

Over the past decade, a number of studies have been conducted that focus on the use of digital libraries and information in the humanities (Marchionini & Crane, 1994; Bates, Wilde, & Siegfried, 1993; Bates, Wilde, & Siegfried, 1995; Bates, 1996). More recent contributions to the field include the work of Crane, (2003) who focused specifically on cultural heritage digital libraries while Buchanan (2005) investigated the information-seeking behavior of humanities scholars.

To date, we have little understanding of the effectiveness and the actual use of digital resources in the classroom. As Borgman (2005) notes, investigations into how educators search for materials or how they use the digital resources to support instruction are still scarce.

While an increasing number of scholars and educators recognize the pedagogical value of web-based resources and encourage their use in the classroom, not much is known on their actual employment in day-by-day teaching and learning practices. In recent years efforts have been directed toward building educational digital repositories of teaching and high-quality learning resources, primarily in the form of learning objects. A significant contribution was made by a large-scale study produced by the Center for Studies in Higher Education at University of California Berkeley. The study investigated the use, as well as the users, of digital resources in the humanities and social sciences in undergraduate education (Harley et al., 2006). The findings showed that faculty integrate digital primary resources into their teaching to improve students'

learning. Their personal teaching styles and methods had a stronger influence on how educators use digital materials than other factors, including institutional, disciplinary, or demographic characteristics. The study found that faculty use an array of digital resources, with differences related to their subject or discipline. For example, political science instructors drew heavily upon data sets while art, architecture, history, and anthropology instructors preferred images. When searching for digital resources, teachers relied on Google as their primary search service. A significant number also used their personal digital image collections as a resource for their teaching. They preferred to personally aggregate classroom materials by mixing their own collections with resources collected from other sources. The study also identified some of the reasons why digital resources are often underused by teachers. For example, some faculty insist that digital resources simply do not mesh with their approach to teaching. Others find it difficult to overcome the technical and financial barriers, including the availability, reliability, and high cost of computer and Internet access necessary to make effective use of digital materials in the classroom. They also indicated the lack of time as one of the main constraints in the use of digital resources.

In the context of middle and high school teachers, the Effective Access Project produced useful data on how teachers access and use web-based educational resources (Carlson & Reidy, 2004; Hanson & Carlson, 2005). Through a series of surveys, focus groups, and telephone interviews, the authors examined twenty-five high school science, technology, engineering, and mathematics (STEM) educators to provide feedback for educational resource developers as they improve the design and integration of digital educational resources into the classroom. The study found that while digital educational resources have changed teachers' practices, the change was not always positive. In many ways, teachers felt their instruction was less efficient and therefore less effective. Findings highlighted that time required to find appropriate resource online was a

major source of frustration. Teachers typically had to go from site to site to find appropriate resources. No one site or search was sufficient. The starting point for searching was usually a commercial search engine such as Yahoo or Google, and sometimes a favorite educational site. The findings highlighted a number of design features that teachers would like to find on a website of educational resources including "searching capabilities, methods for submitting questions, links to related materials, and the assurance that the website is supported by a reputable sources" (Carlson & Reidy, 2004, p. 69). In general, the way web resources are integrated into the classroom is very similar to how print materials would be. With their findings, the study's authors aimed to "create a bridge between the needs of teachers and the work of developers" (p. 69).

Through its annual evaluation reports, the Gateway to Educational Materials (GEM)[28] provides perspectives on the end uses of online educational resources for K-12 education. In the fourth GEM annual report, Fitzgerald, Lovin, and Branch (2003) identified the main assumptions behind the need for an educational gateway to learning resources like GEM. Educational materials available on the Internet can be of equally high and poor quality and therefore require considerable effort both for discovery and selection. Teachers lack the time needed for such careful analysis which often hinders their ability to plan and integrate technology into their teaching.

The findings of GEM are supported by the educational literature indicating that teachers persistently experience a shortage of time for preparation, primarily due to their heavy workloads (Smagorinsky, 1999; Swaim & Swaim, 1999). Searching the web for educational resources is a process perceived as time consuming and frustrating (Voorbij, 1999). Finding digital content that is aligned with a particular lesson can be extremely difficult (Trotter, 1999), while even more

[28] http://www.thegateway.org/.

daunting is the discovery of highly-specific content that meets the needs of the curriculum requirements (Robertson, 1999). Although the web presents an almost unlimited source of materials and ideas for teaching with thousands of collections of educational materials freely available, accessing this massive amount of content can be difficult. Lack of a unified search system is one of the main hindering factors behind teachers' inability to find suitable digital materials quickly and easily (Small, Sutton, Miwa, Urfels, & Eisenberg, 1998).

2.4.3. Digital Libraries in History Education

Studies devoted to the use of digital libraries in history education are relatively scarce. More needs to be known about the habits, needs and behavior of history educators as well as historians in relation to the discovery and use of historical resources in digital format. The scarcity of knowledge about historians and the need for archivists to conduct systematic user studies to gain a better understanding of the historical data users need has been stressed by Tibbo (2002). Tibbo's preliminary findings revealed that traditional habits tied to the printing world often prevail in the process of seeking historical resources, and this behavior hinders the full exploitation of the opportunities that technology brings. Similarly, Toms (2002) investigated the use of archives and finding aids by graduate students through their experience using diaries and Duff (2002) conducted interviews of historians to understand their seeking behavior in archives. Findings reveal that two types of behaviors are intertwined and equally relevant to historians: the identification of relevant content and contextual understanding. Context is the foundation of historical research and "without it historians are unable to understand or interpret the events or activities that they are examining" (Duff & Johnson, 2002, p. 486). Interpretation of the past is highly dependent upon contextual knowledge. In fact, when examined in relation to each other and in their totality, documents and records convey incomparably more information than when

considered individually. Furthermore, "contextual knowledge is also critical for identifying relevant material" (p. 488). For example, contextual knowledge may help users navigate finding aids more efficiently during the search process. As for the discovery of relevant materials, historians interviewed expressed a desire to have subject access to the collections, a practice that is not common in archives. They also suggested that subject headings, keywords, and the identification of themes would facilitate their search process. "There has to be a way that people can find things without having to know who generates them so that keywords will search across different provenance of things" (Duff & Johnson, 2002, p. 493-494).

Choi and Rasmussen (2003) analyzed historians' search for digital images using query analysis. The findings revealed that access points to images were primarily by time period, geographical division, and format of images. In her review of the relevant literature, Smith (2004) identified several unique characteristics of historians when seeking for information. For example, historians have a preference for browsing over searching because of the serendipity component of the browsing function.

Numerous papers in Smith's review of the literature converge on the fact that historians are strongly interested in primary sources because, for methodological reasons, they need to work with materials that are as close as possible to the historical period or event they analyze. Access to primary sources is essential to historians' work and they tend to use a variety of types of materials and take an interdisciplinary approach to their research (Dalton & Charnigo, 2004). The way historians search for primary source materials has changed over the years, especially with the advent of the Internet. In the past, historians used bibliographies, book reviews, references in books or journals, catalog abstracts, or indexes as their primary discovery tools (Stieg, 1981). More recently, they have increased their use of electronic indexes and catalogs while maintaining some print resources for discovery. How historians organize and assign

categories to information is highly influenced by their contextual perspective. A study by Case (1991) found that historians frequently used metaphors and subjective categories to describe the documents they collected. Because of their unique descriptive needs, historians "may be less well served by classification and indexing than any other academic field" (p. 79).

2.4.4. Instructional Use of Primary Sources

In recent years, digital collections of primary source materials[29] have become widely available and openly accessible on the web. The Library of Congress' American Memory Project,[30] the University of Virginia's Valley of the Shadow,[31] and the California Digital Library[32] are just a few examples of the wide array of digital collections of historical resources available. These digital historical resources offer enormous opportunities for history educators and students as well as historians and have the potential to profoundly impact the way we study the past (Friedman, 2005).

Web-based primary sources represent a completely new wellspring of data that can make history "more richly documented, more accessible, more diverse, more responsive to future researchers, and above all more democratic" (Cohen & Rosenzweig, 2006, p. 248). Digital history has emerged as a specific discipline that studies "the past using electronically reproduced primary source texts, images, and artifacts as well as the constructed historical narratives, accounts, or presentations that result from digital historical inquiry" (Lee, 2002). Digital resources and digital libraries are producing radical changes in the way academic disciplines are

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[29] Digital resources are recognized as one of the five categories identified as primary sources in the context of history teaching (Danzer & Newman, 1996, p. 24).

[30] http://memory.loc.gov/ammem/index.html.

[31] http://valley.vcdh.virginia.edu/.

[32] http://www.cdlib.org/.

conceptualized, forcing scholars to recast the nature of their disciplines in the light of the new information technologies. While the implications of the use of digital primary sources for history and social studies education have not yet been fully explored, they have the potential to be the "catalyst to transform teacher education" and to deeply transform the traditional history classrooms beyond the memorization and recitation of facts (Bolick, Hicks, Lee, Molebash, & Doolittle, 2004, p. 200).

Developing students' historical thinking skills has become a major objective in current pedagogy and represents a serious challenge for teachers. There is a clear theme in the educational literature that the traditional textbook-driven approach to the teaching of history has been thrown into question. Textbooks embody the idea of history as an objective account of reality that contrasts with the principles of inquiry-based learning embraced by today's pedagogy. Direct analysis of primary sources is seen as an important alternative to the traditional memorization of facts from the textbook (Kobrin, 1996). Although textbooks have started to incorporate more primary sources such as maps, photographs, illustrations, and excerpts from primary source texts, as Newmark (1997) notes, they are usually just peripheral additions to the traditional way the textbook addresses topics and "tend to be more decorative than informative" (p. 283). The use of digital primary sources in the classroom is considered essential to engage students in learning activities that encourage critical thinking in studying historical events and the diversity of viewpoints that define the past (Tally & Goldenberg, 2005). Through exposure to interpretative activities, students have the opportunity to broaden their perspectives of the world and develop an inquisitive attitude which may lead to further questions and research (Otten, 1998). Primary source materials integrated into the classroom offer ways to involve the students in analytical activities that help them relate to the past and interpret it based on evidence (Cantu & Wilson, 2003). Through the analysis of primary documents students may gain the sense of the

past as a complex and constructed reality. While available in the past only to a limited number of users, primarily historians, web-based primary documents are now accessible to a variety of communities of users, including teachers and students at any level and grade. Lee (2002) points out how the web not only facilitates a wide dissemination and open access to resources, but also enables a flexible and interactive approach to history that exposes students to new insights about historical content not possible with books.

Students' interest in history is stimulated when past content can be approached in ways that are relevant to their lives. Digital primary sources, especially of local history, are seen as essential for creating "meaningful history experiences for students" (Clarke & Lee, 2004, p.84). The reconstruction of personalized stories from the past is a powerful way to help students connect to their community as well as to identify themselves in a broader historical context. The National Center for History in the Schools' (NCHS) publication *National Standards for History* (1996) contends that "historical memory is the key to self-identity, to seeing one's connectedness with all humankind" (p. 1). The study of local history allows students to identify themselves within an historical context and also to recognize "shared humanity and common problems" regardless of time or place (p. 42). The study of personal or local history helps students make sense of larger narratives about the past.

A new type of inquiry-based education is emerging that involves a process where "students have to learn what it is to ask and answer historical questions – how to find information, how to evaluate sources, how to reconcile conflicting accounts, how to create an interpretative account" (Levstik & Barton, 2000, p. 14). This instructional approach has the potential to radically subvert the traditional history teaching. However, implementing such a perspective is very challenging and history and social studies teachers are in general not

adequately prepared to do so (Bolick et al., 2004). Regardless, it is clear that digital primary sources will play an increasingly important role in the teaching and learning of history.

2.4.5. Use of Digital Primary Sources in Higher Education

According to Lee and Hicks (2003), teachers at the college and university level are the most active users of digital historical resources for instruction. A recent study of college students demonstrates that those who use the web are more inclined to focus on primary sources and analyze their meaning instead of simply memorizing facts. Moreover, when exploring the web, students appear to be more stimulated to reflect upon the past in an original way, a process facilitated by relating sources to one another and making connections between events and people that are not evident from the textbook (Kelly, 2000, p. 2). Putting fragmented documents in relation to each other to create a historical narrative is one of the most important processes involved in thinking and learning about history (Wineburg, 1994). Web-based primary sources facilitate activities that enable students to question historical events and develop skills of interpretation that represent the basis of historical comprehension. Indeed, learning history can be seen as a process that involves the construction of historical meaning through analysis of cause and effect, comparison of different perspectives, and contextualization of documents. All of this is rather distant from the passive absorption of facts from lectures and textbooks.

2.4.6. Use of Digital Primary Sources in K-12 Education

In 1996, the National Center for History in the Schools at the University of California, Los Angeles under the guidance of the National Council for History Standards published the *National Standards for History*. Throughout the work, the use of primary source documents is stressed. Despite the relatively limited access to primary source materials at the time, their

importance to the teaching of history, even in the K-12 environment was clear. With the advent of the web and the expansion of collections of primary source materials available, assumptions were made that K-12 education would be transformed. Yet, even today, especially compared to higher education, social studies teachers in grades K-12 make limited use of the computer technology and digital resources available. In a national survey of over 4,000 social studies teachers, less than 20% were regularly using computers for instruction (Becker & Miel, 2000). As for high school social studies teachers, a 2002 national survey showed that more than 50% use digital historical resources less than once a month or never (Lee & Hicks, 2003).

As for the students, only one out of three uses a computer to "study history" at least once every few weeks (Lapp, Grigg, & Tay-Lim, 2002).[33] The benefits of using primary sources in high school history classes have been emphasized for developing the "habit of minds" of historians in students (Warren, 1999). Historical skills are obtained through the analysis of historical resources and a critical construction of history. Warren argues that an effective method to encourage historical inquiry and increase interest in historical subjects in high school students is to engage them in hands-on instructional activities. The benefits of primary source-based exercises may largely compensate for the instructional time they require.

To date, the unique opportunities that digital history offers for transforming the history and social studies classroom have yet to be fully exploited. Bolick et al. (2004) stress the existence of a gap between the expectations and the actual use of the new technology for instruction. A number of instructional issues are still open and difficult to address. For example, despite the encouragement from the national standards to incorporate primary documents into their instruction, teachers are not well-versed on how to reconcile them with the standardized tests that are the dominant measure of academic success in U.S. education.

[33] Results of a survey conducted in 2001 by the National Assessment of Educational Progress (NAEP) for U.S. History students in grades 4, 8, and 12.

Research on the use of digital resources in social studies education is also limited. The literature generally refers to specific educational websites and digital historical resources,[34] such as the successful Shadow of the Valley[35] and History Matters,[36] but it tends to be more descriptive than analytical. Instructional use of digital primary sources in K-12 was investigated in a series of pioneering studies conducted in the mid 1990s by the Library of Congress. First, an evaluation of the American Memory Project was conducted between 1991 and 1993 (American Memory User Evaluation Team (2003). The findings revealed a strong interest in using digitized materials not only from higher education and digital libraries that were considered the ultimate audiences, but also from K-12 teachers. This category of educators "contributed the largest share of ideas about using American Memory materials – everything from illustrating a report or a presentation to creating a diary or a historical "period" newspaper using American Memory materials" (p. 83). Also, a user study intended to launch and evaluate a pilot of the Library of Congress' American Memory project was run from 1990 to 1995 and provided the feedback and inspiration for the development of the larger National Digital Library Program (NDLP). The American Memory pilot identified the need for historical primary sources in instruction as the result of reforms that had just taken place in education. Also, participants suggested that content should relate to school curricula for more effective instructional use (The Library of Congress, 1995). Moreover, a subsequent educator's forum brought together history and social studies K-12 teachers and librarians to discuss how to best use on-line primary sources in the classroom. Participants identified effective ways to "package and deliver" the Library's historical digital resources for use in K-12 grade education. Teachers suggested creative uses of the documents,

[34] A list of high quality resources developed at colleges and universities and at K-12 schools is provided by Lee (2002).

[35] Developed at the University of Virginia and available at http://valley.vcdh.virginia.edu/.

[36] Developed at George Mason University and the City University of New York and available at http://historymatters.gmu.edu/.

especially visual resources like photographs and posters, to support discussions of social and economic changes over time (e.g., "from a rural to an industrial economy") as well as important cultural transformations (e.g., "women's roles of the 1940s with those of the 1950s") (The Library of Congress, 1995).

A more recent study involving Colorado educators also addressed the use of digital primary sources in K-12 teaching (Bloom & Stout, 2005). Once again, the lack of awareness and the lack of time to find digital primary sources appropriate for the curriculum were identified as the main obstacles to the broader use of these materials in the classroom. Online digitized primary sources were used by teachers to cover the content and also teach the skills prescribed by state teaching standards. Analyzing historic photographs or comparing and contrasting different historic newspapers are among the instructional activities supported by primary sources collections such as Library of Congress' American Memory or the Colorado's Historic Newspaper Collection.[37] The study demonstrated that the availability of these materials offered an unprecedented opportunity to teach history in an effective way. For example, the use of images (e.g., photographs, political cartoons, etc.) has the potential to trigger students' visual imagery and facilitate the understanding and consolidate the retention of textual information. The study recommended strategies to help make primary sources more accessible for educators and students. One way is to add an educator section to a website that highlights materials relevant to or tied to the curriculum. Another way is by classifying and presenting primary sources by time, geography, theme, or subject, in addition to keywords. Primary sources organized by themes or grouped in chronological sets and keyed to major periods in U.S. history, as in The American Memory Timeline,[38] are other ways to help teachers find relevant resources more easily.

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[37] http://www.cdpheritage.org/collection/chnc.cfm.

[38] http://memory.loc.gov/learn/features/timeline/index.html.

2.4.7. Seeking Digital Primary Sources in K-12 Education

A pilot user study conducted within the Open Archives Initiative Metadata Harvesting Project at the University of Illinois at Urbana-Champaign with K-12 teachers-in-training sheds light on how teachers seek for digital primary sources and what criteria they use in choosing such sources for classroom instruction. The project tested the searchability of a portal with aggregated metadata for cultural heritage resources. One of the study's findings revealed that educators prefer contextualized primary sources. Participants explicitly pointed out that "after discovering a topic-specific data provider through the UIUC portal, they preferred to go directly to the data provider site to find additional material on their topic and to view these materials in a subject-specific context." Other findings reflected the expectations and frustrations participants had about the content that they thought should be available from a "cultural heritage" portal. One of the key discussion points was about how to "help users form a mental map of the subject areas that are covered and those that are excluded" so that "users may thus be given a better sense of the collection 'landscape' they are exploring" (Shreeves & Kirkham, 2004).

An important contribution to the literature and pertinent to this study was conducted by McGlinn in 2007. McGlinn investigated the access and use of the Documenting the American South (DocSouth)[39] digital library by social studies instructors. The study's findings revealed that, while the primary sources in DocSouth are perceived by the teachers to be valuable for instruction, their use in the classroom was limited due to three main factors: 1) the schedule imposed by the standard course of study; 2) the availability of computer equipment and Internet access and 3) the sheer magnitude of the content. Specifically, teachers complained that the depth and breadth of DocSouth made it difficult for them to locate sizable materials suitable for

[39] http://docsouth.unc.edu/.

class activities even when they were aware of their existence within the digital library. As McGlinn argues, even if teachers are able to overcome the technical challenges of teaching with digital resources and the difficulty in finding quality resources, they still face the novel pedagogical challenge of finding creative ways to use the resources so they advance an inquiry-based approach to history teaching and learning.

A related study of the DocSouth digital library consisted of a series of usability tests and focus groups that included middle and high school teachers from North Carolina. The study was conducted to inform the redesign of the DocSouth website and revealed that the use of the library's digital collections were "task oriented and context dependent" (Norberg et al., 2005, p.295). The study indicated that one of the greatest barriers to using digital materials in the classroom was the familiar constraint of the time needed to identify appropriate materials. Other studies concur that teachers often lack the time needed to search through the massive amounts of digital materials available on the web (Carlson & Reidy, 2004; Small et al., 1998). The literature on the time constraints teachers face in their worklife is extensive. A Fitzgerald (2003) notes: "They have heavy workloads and very little time for preparation" (p. 26). Teachers often have difficulty constructing search queries within digital libraries (Recker et al., 2004) and in general do not want to spend time keyword searching.

Teachers using DocSouth also lamented that manuscripts and other text documents were too large to be used by students and suggested that pre-selected "key" segments or excerpts of the texts would be helpful. To improve access to the collection teachers suggested that the collections of images be logically indexed by broad subject or theme. (Norberg et al., 2005).

2.4.8. The Influence of Curriculum Standards

The need to improve the academic achievement of schools in the U.S. resulted in a set of national standards for the teaching of social studies, including history. A curriculum standard is defined as "a statement of what should occur programmatically in the formal schooling process; it provides a guiding vision of content and purpose" (National Council for the Social Studies, 2006).

The two major sources of standards for history that have also inspired many state standards are the NCHS publication *National Standards for History* (National Center for History in the Schools, 1996) and the National Council for the Social Studies (NCSS) *Curriculum standards for social studies* (National Council for the Social Studies, 1994). Both tools emphasize the importance of incorporating methodologies that are proper to historians in the teaching of history (Cantu & Wilson, 2003). The national standards for middle and high school grades address five components of history comprehension: chronological thinking, historical comprehension, historical analysis and interpretation, historical research capabilities, and historical issues analysis and decision-making. They stress the development of historical inquiry skills that involve the ability to formulate questions and provide interpretations based on evidence. Some of the skills students should be able to perform in order to think as historians include: comparing and contrasting various sets of ideas, examining different perspectives on the issues and beliefs of society, and analyzing cause-and-effect relationships while taking into consideration multiple factors (Organization of American Historians, 2005). Teaching and learning strategies proposed in these standards entail the use of primary source materials as essential for fostering the historians' "habit of mind" (Cantu & Wilson, 2003, p. 24).

Similarly, the NCSS standards highlight the importance of studying and interpreting primary sources. Developed for teachers seeking certification in social studies, the NCSS

standards recommend an interdisciplinary approach to five disciplines (history among them) and a special focus on citizenship education. Studying the past is considered essential for understanding contemporary issues and teaching methods that engage students in research and experiments and incorporate hands-on activities best address that goal. NCSS standards are considered a flexible tool that guides teachers towards an active, reflective, and inquiry-based teaching style.

The NCSS explicitly encourages the use of technology in instruction by stating that "integrated social studies teaching and learning include effective use of technology that can add important dimensions to students' learning" (National Council for the Social Studies, 1994, p. 165). The NCSS identified a series of thematic strands that can form the basis of a learning unit in social studies. Most of the strands encourage the use of primary sources, in particular the "Time, Continuity and Change" thematic strand (National Council for the Social Studies, 1994, p. 22).

According to Marchionini et al. (2003), "teachers' needs are actualized in curriculum standards and guidelines" (p. 131). Specifically, the dialectic between teaching standards that define the content to be covered in the classroom and current pedagogical practices that emphasize the development of historical thinking skills are often in conflict. Two different perspectives are at the core of this discussion. Those responsible for the standards stress the importance of *what* to learn. They emphasize the importance of the subject matter as a way to provide a common ground for the foundation of national unity. On the other side are teacher educators who, while they do not dismiss the importance of content, tend to value the *how* of learning and reject the idea of defining what the "right" history is. They believe that history can be taught in a number of different ways and critical thinking is the foundation for developing active citizenship, the true key to a united and democratic nation (Kobrin, 1996).

The *what* and *how* of teaching and learning history are also determined by standardized tests of each state. Introduced as a requirement in public schools in 1994,[40] the No Child Left Behind Act[41] has increased the weight of standardized testing that ties public school funding to performance scores. The increased emphasis on testing is considered by a large segment of K-12 educators to be responsible for marginalizing history education. It reduces the content covered in the classroom and discourages the intellectual investment of students (Kornblith & Lasser, 2004). It is seen by many as a return to the "factory model" of K-12 education of the past where the same standardized units of information were delivered to each student and tailored to the single goal of passing an objective exam.

3. Conclusion

This review of the literature established the context for this study. It provides an overview of the current literature on ontologies and highlights its potential for enhancing access to web content. This review also demonstrates the need for studies on the use of digital primary sources by educators, especially middle and high school social studies teachers. The literature reviewed in this chapter suggests that an ontology could help history and social studies teachers use collections of primary materials in their teaching. An overview of research to investigate this idea is presented in Chapter 3.

[40] The Elementary and Secondary Education Act (ESEA) (Public Law 89-10, 79 Stat. 77, 20 U.S.C. 70).

[41] US Public Law 107-110 introduced in 2001.

CHAPTER 3

STUDY OVERVIEW

3.1. Research Questions

There is consensus in the literature that primary source materials are a key component in inquiry-based teaching and learning. Although available on the web in great quantity, digital primary sources are largely under-utilized, especially by primary and secondary educators. The limited time teachers have for class planning and classroom instruction and the challenges of finding suitable digital primary sources quickly and easily are among the reasons reported for this low use. In an effort to make their digital collections more accessible to K-12 teachers, the UNC-CH University Library repackaged a digitized report related to the Great Depression and Roosevelt's New Deal into a collection of reusable learning objects. Still, library staff members recognize that access to the collection of learning objects remains a problem.

The literature also suggests that a domain ontology has the potential to improve the discovery of digital resources and may prove useful to teachers when searching for primary sources for teaching and learning, but few studies have addressed the process of developing a domain ontology for this specific user group (and rarely for any specific group) or the application of an ontology to a collection of digital primary sources. As a result, this study focused on building a domain-specific ontology to enhance access to a collection of learning objects.

Domain ontologies are by definition models of specific knowledge areas or domains of interest. Modeling a domain is not a neutral activity and the developers are responsible for making choices that will have an impact on the effectiveness and also the usefulness of the tool. How does one design an ontology that will be useful to teachers in supporting their seeking needs? This expresses the principal research question underlying the entire study. Getting to understand the teachers as the final users of the ontology-based system may seem an obvious answer. However, ontologies are typically developed without conducting deep analysis of end users' needs, and their direct involvement in the process is almost nonexistent. This study proposed a different methodological perspective to ontology development in which end users are called on to play a key role in guiding the design of the ontology.

Verifying whether or not an ontology developed from such an approach will be appropriate for the audience and thereby useful in meeting their objectives is the primary goal of this dissertation. The goal is addressed by investigating the following two research questions:

1) Is the ontology model appropriate to capture and represent teachers' searching needs?

2) Is the ontology perceived to be useful by the teachers in their seeking process?

These questions are answered through an evaluation study conducted with the involvement of social studies teachers representing the end users of the ontology.

3.2. Significance of the Study

One of the significant elements of this study is the involvement of end users in the ontology development process, which represents a rather new approach in ontology engineering. To accomplish this, two additional steps in the development process have been included in the general methodological framework: a series of in-depth interviews with intended end users to provide direction to the design of the ontology and an evaluation study in the early phase of the

ontology construction. These additions are intended to strengthen the process of ontology construction from a user-centered perspective. Moreover, the methods devised to evaluate the ontology present elements of novelty and may have implications for adoption in further user studies.

Finally, the TBS Ontology developed within the study, although still in an early stage, represents one of the few attempts at modeling a portion of the domain of U.S. History and may provide a reference model for other developers.

3.3. Research Overview

The study proceeded in three phases. In Phase I, a series of in-depth interviews intended to investigate history and social studies teachers' instructional practices, information needs, and expectations was conducted to gather background information that would inform the ontology design. Specifically, the interviews were aimed at gathering information on the teachers' perspectives on the content domain they address in their teaching, their context of use, and their preferences in terms of access and use of the digital primary sources.

In Phase II, an ontology model was designed to represent a sub-domain of North Carolina History and reflect the subject area of the TBS collection of digital objects. The development methodology included the specification, knowledge acquisition, and conceptualization phases. The outcome of this phase was a model prototype, or *seed ontology*.

In Phase III, a user-centered evaluation of the seed ontology was conducted to test the quality of the design of the ontology model and its usefulness as perceived by the intended community of end users.

Phase I and Phase III studies were approved by the University of North Carolina at Chapel Hill Institutional Review Board. The three phases and their results are presented in the

next three chapters. The findings from all the phases are then discussed and synthesized in Chapter 7.

CHAPTER 4

PHASE I: INTERVIEW WITH TEACHERS

A series of in-depth interviews was conducted to investigate the information seeking behavior, needs, practices, and expectations of educators who use digital primary source materials in the classroom. The purpose of the study was to gather background information and identify the functional requirements that should be addressed in the design of the ontology.

4.1. Procedures

High school and middle school social studies teachers were invited to participate in the interviews. This pool of participants was chosen because it represented the primary audience for the TBS learning object collection identified by the staff of the UNC University Library and the faculty at the UNC School of Education. Every effort was made to recruit study participants who represented different demographics, including age, race, and sex. Teacher participants were all familiar with primary sources, having used them before in their teaching and research.

By conducting individual interviews, the researcher intended to explore the issues surrounding the search for, and use of, digital primary source materials in the classroom. For that reason, only participants who had used digital primary resources were invited to participate. Subjects were recruited by direct solicitation through an e-mail sent to the list of participants in the DocSouth Teachers' Summer Institutes and the list of the cohort of students enrolled in the

UNC Master of Education for Experienced Teachers program obtained from the School of Education.

Six social studies teachers from high schools and middle schools throughout Chapel Hill and the surrounding areas were interviewed during the summer of 2006. The interviews were conducted in person in the participants' schools (two cases) and on the UNC campus (four cases). Each interview lasted an average of forty minutes. The interview protocol included ten questions (See Appendix I) intended to elicit information on how teachers use primary sources in the classroom, how they search and find primary sources, and the broader context of their teaching of history. The semi-structured format of the interviews allowed for focusing on specific questions and question areas, while offering participants an opportunity to give additional feedback and elaborate further on any aspect of their experience they considered relevant to the study. Through the use of open-ended questions, participants were invited to provide examples related to their professional experience.

4.2. Data Analysis

Interview data was collected through audio-recordings and the investigator's written field notes. Verbatim transcriptions were created and transcripts were coded using the constant comparative method of qualitative analysis to help identify and interpret common themes and patterns (Glaser, 1967). The interviews were analyzed using the qualitative data analysis system Atlas.ti.

Demographic information was collected at the beginning of the interview (see Appendix II). The pool of participants was evenly distributed by sex with ages spanning from twenty-five to over fifty. Five out of the six participants were teaching history courses at the time of the study, in grades 6th to 12th. The sixth participant was teaching at the college level, but she had

taught 6th, 7th, and 8th grade classes in the recent past. Their teaching experience spanned from one to twenty-nine years and their education included two bachelor degrees in history and one in education, and three master degrees, two in social studies and one in education.

The six teachers taught in both suburban and rural schools, medium to large in size. The student body population of each school differed slightly in economic status but the majority were middle class and predominantly white. Teacher participants were all trained in the use of technology for instruction. All had Internet access in their classrooms, except for one classroom.

4.3 Trustworthiness of Results

In-depth semi-structured interviews were adopted as the primary strategy for data collection in Phase I of the study. This research method was deemed appropriate for the research aims of this segment of the study: to learn about individual teachers' experiences, needs, and difficulties surrounding a single topic, the use of digital primary source material in their classrooms. This type of research method is descriptive and its procedures must be responsive to the participants' contributions. Therefore, the study's rigor and the trustworthiness of its findings are critical issues to be addressed.

As long discussed in the literature, the traditional criteria of validity and reliability that establish trustworthiness in quantitative research are not appropriate for qualitative research. Four criteria to evaluate trustworthiness in a qualitative study have been proposed: credibility, transferability, dependability, and confirmability. These four criteria are reasonably comparable to those used in quantitative research: internal validity, external validity, reliability, and objectivity (Lincoln & Guba, 1985). Strategies to minimize research bias and maximize the validity of the study findings are framed in terms of these set of criteria.

4.3.1. Credibility

Credibility corresponds to internal validity and refers to how believable the findings are. The richness of the information gathered and the analytical ability of the researcher are important factors in ensuring credibility (Creswell, 1998; Krathwohl, 1998; Lincoln & Guba, 1985; Patton, 1990). Another important indicator for evaluating whether the study's findings and interpretations are credible is the rigor with which the study was conducted (Merriam, 2002).

One strategy to improve credibility is referential adequacy. In this study, referential adequacy was established by the adoption of systematic research procedures to collect data that would make the findings open to critical examination. For example, an interview protocol or "schedule" (see Appendix I) was adopted that served to ensure that the same information was elicited from each subject while the semistructured format of the interview allowed other topics to emerge that were specific to individual experiences. This minimized "the imposition of predetermined responses when gathering data" (Patton, 1990, p. 295), while ensuring consistency and comprehensiveness of the responses. Also, the interviews were tape-recorded and the recordings were later transcribed verbatim. This step eliminated the need to rely solely on the researcher's memory of the interviews, as another means of ensuring credibility (Patton, 1990).

Credibility can be affected by the method used for sampling. The purposive sampling technique was adopted for selecting study participants. This method requires selecting subjects that have the potential to provide rich information that would facilitate a deep understanding of the phenomenon or situation being investigated (Patton, 1990). Indeed, purposive sampling allows the researcher "to understand the particular in depth, not to find out what is generally true among many" (Merriam, 2002, p. 28). Therefore, the size of the sample is typically small and non-random. For this reason it cannot be generalized statistically. As Patton (1990) points out,

credibility is more dependent upon the richness of the information yielded and the observational capabilities of the investigator than on the size of the sample.

Six participants were selected for interviews. The selection criteria for study participants were that they have experience teaching social studies at the grade level and have experience using digital primary sources for instruction. A list of 18 potential participants was provided by the School of Education that included attendees of the DocSouth Teachers' Summer Institutes as well as students enrolled in the UNC Master of Education for Experienced Teachers program. These potential participants represented good candidates for the study because they all met the selection criteria and were also likely to provide rich and detailed information. Six subjects agreed to participate in the study. Hence, convenience in terms of availability and willingness were also factors that determined the selection of the sample. Although not representative of the population group because of the small size and the limited geographic area where all participants lived and worked, this sample was highly informative and consistent with the purpose of the study. Due mostly to the homogeneity of their backgrounds and work contexts, participants offered perspectives that were largely consistent with each other. While this circumstance was useful for yielding in-depth information, it would discourage the idea of generalizing the study conclusions to other groups of teachers.

4.3.2. Transferability

Transferability, or external validity, refers to how the research findings are generalizable to different groups or other settings. Transferability of findings greatly depends on the similarity of the original study situation to the new one. To avoid the inappropriate transfer of the findings, a detailed description of the study procedures has been provided that may enable readers to decide whether the findings are transferable to other contexts. As Patton (1990) suggests,

presenting "solid descriptive data" or "thick description" is another strategy to improve transferability (p. 375). According to Holloway (1997), ‘‘Thick description builds up a clear picture of the individuals and groups in the context of their culture and the setting in which they live’’ (p. 154). In the section discussing the findings of the study, extensive quotations from participants are presented. Moreover, the context of the practices and discourse of the participants’ community was described in detail to contribute to the ‘‘thick description.’’ As Ponterotto (2006) points out, from a densely described discussion of qualitative interview results, “The reader is… able to digest the essential elements of the findings, and is able to discern whether she or he would have come to the same interpretive conclusions as the report’s author” (p. 547). In fact, the responsibility of the researcher to insure transferability is in contributing “sufficient descriptive data” that would make it possible for others to decide whether the study findings are applicable in other contexts (Lincoln & Guba, 1985, p. 298).

Triangulation is another operational technique that can be used to improve transferability. Within the context of this study, interview data was triangulated with the literature review that had preceeded the study in order to strengthen the results. Indeed, the two sources of data were mostly in agreement and corroborated each other.

4.3.3. Dependability

Dependability or reliability refers to the replicability and consistency of the study. The idea of replicability has been questioned since, in qualitative research, the same set of data is prone to different interpretations (Merriam, 2002). Consistency is considered more significant for assessing the quality and validity of a study (‘‘the important question for qualitative researchers is *whether the results are consistent with the data collected*’’ (p. 27, emphasis in

original). In other words, dependability is primarily concerned with how well the findings reflect participants' expressed views and how free they are from the researcher's biases.

To ensure dependability, the researcher reported rich descriptions of the interview responses in the discussion of the findings in order to substantiate interpretations and show multiple perspectives. The numerous passages from the interviews reported in the study helped to give voice to participants ("presence of voice in the text" (Eisner, 1991, p. 36) and reduce the potential effects of the researcher's biases.

Another strategy to enhance dependability is to properly manage and accurately maintain researcher field notes, transcripts, and materials from the data analysis process according to the research procedures and make possible an external check on the study processes (external audit) (Lincoln & Guba, 1985). These recommendations have been closely followed in the procedures of the study while respecting the privacy of the study participants.

4.3.4. Confirmability

Confirmability is comparable to objectivity in quantitative research that refers to the degree of neutrality of interpretation a study carries. In qualitative research, where the unique perspective of the researcher is considered a normal condition, this criterion is interpreted in terms of the extent to which the study results could be confirmed by others (Hoepfl, 1997). A major strategy to enhance confirmability is to conduct an external audit or "audit trail" that would examine the data collected and the procedures adopted to assess potential bias (Lincoln & Guba, 1985, p. 319). Another way to establish confirmability is by searching for *negative instances* that contradict previous observations. This requires documenting the procedures for being able to check data throughout the study. Within the context of the interview study, negative instances have not been identified. However, a negative instance emerged in Phase III

when the limited range of search strategies participants showed while performing searching tasks contrasted with the diversified search approaches interviewees had described when they were interviewed about how they usually search or wish to search for primary sources, as discussed in Chapter 6. This discrepancy seems to have to do mostly with the normal gap between actual practices and description of hypothetical situations and/or the artificial setting of Phase III search tasks. In the overall dissertation study, the quality and reliability of the data collected during the interviews that served to guide the design of the ontology were confirmed, although implicitly, by the positive outcome of the evaluation of the ontology.

4.3.5. Conclusion

This section has described the techniques adopted in this qualitative study to minimize research bias and maximize the validity of the study findings. These techniques have been presented within a framework of four criteria: credibility, transferability, dependability, and confirmability intended to establish trustworthiness in qualitative research.

The interview findings are presented below in sections that address aspects of the use of primary sources by the teachers, the role of educational standards and standardized testing in delivering instruction, and the search strategies, habits, problems, and expectations of the teachers.

4.4. Use of Primary Source Materials

4.4.1. How Often Primary Sources Are Used

Five out of six participants used primary source materials frequently (at least once a week) and some of them extensively (more than twice a week), making primary sources a central

component of their history teaching practice. One teacher had only limited experience with the use of primary sources in the classroom due to her status as a relatively novice teacher. Nevertheless, she was knowledgeable about primary sources, having participated in a DocSouth Teachers' Summer Institute that addressed the use of digital historical collections for instruction.

4.4.2. How Primary Sources Are Used

Participants used primary sources in a variety of ways, including reading activities and classroom projects. Primary source documents, especially images, were typically projected onto a computer-projector screen or, when technical equipment was not available, presented to students in a photocopied or printed format. In reading activities, primary sources were often the center of class discussions. For example, one of the participants mentioned: "I read them to the class and then I have the kids either produce some kind of Q&A and opinions based on questions. With my honor-level class, I usually use primary source documents in support of their arguments and document-based questions."

Comparisons emerged as one of the activities teachers considered most effective when using primary sources in the classroom. Four teachers recognized the value of primary sources for comparing and contrasting different sets of ideas, personalities, and institutions as a way to make students more receptive and inquisitive about the past. One effective method to engage students was by relating the information to people from the past, especially of their own age. As one teacher stated, "I can hook a teenager if I can have here a series of photographs about teenagers who run away from home." Other examples included comparisons of people's lives (e.g., families separated during the Civil War) and opinions and ideas (e.g., those for the New Deal vs. those against the New Deal). One teacher pointed out how useful it was in her

experience to compare issues that affected the lives of ordinary people from the past with the lives of her students, such as the groceries purchased or student life.

One teacher highlighted the importance of addressing the complex nature of historical events. "…teaching history depends on what cause and effect you're talking about." He stressed the risk of being too simplistic when describing events of the past and the need to help students understand the complexity inherent in historical processes.

The pedagogical significance of using primary sources for teaching history was recognized and emphasized by each participant. They viewed primary sources as an effective means of capturing students' imagination with the goal of deepening their understanding of historic events. All participants shared a genuine concern for keeping students interested in the study of history. In the words of one participant: "we are trying to get them on the hook. Average teenagers don't care about history. We get them involved in the topic and this would help with their thinking process." Primary sources represented a useful tool for "grabbing their [students'] attention."

Unlike many of the common practices described in the literature, the textbook had been replaced by primary sources or played a significantly reduced role for the majority of these participants. "Books do what they do, but primary sources give them [the students] the opportunity to make their own decisions on history," one participant stated.

4.4.3. What Kinds of Primary Sources Are Used

Visual and text-based materials are the types of resources participants tend to use most frequently in the classroom. Only one teacher had experience with oral histories. Participants identified first-person narratives as the most effective genre of primary sources. These include diaries, biographies, and letters. Personal narratives can be pivotal for engaging students in the study of history. As one participant noted, "they [personal narratives] bring life into the

classroom" and "make students feel involved in events from the past." First-hand accounts help "make things more real [and] show that history happens to real people just like them."

According to participants, images and photographs have a particularly strong impact on students. They are often used in combination with personal narratives. A learning activity described by one teacher involved the use of photographs to question certain assumptions students held about a particular period. Biographical information related to the photographs was later used as evidence to verify or refute students' hypotheses. The teacher considered this activity effective in promoting an inquisitive approach to history and developing students' critical thinking skills. She also pointed out that it was sensitive to the students' different learning styles.

Participants reported that students immediately understood visual information, and it often gave them an easier introduction to more complex primary sources. "Pictures help with memorization and kids love them," one respondent noted. One participant revealed that his strategy was to show "photographs first and, as [students] get more experience, letters, but it takes time." This strategy was shared by another teacher: "I think sometimes words scare them away, you know. Having a picture with the description of what the picture is always helpful."

4.5 Educational Standards

There was consensus among participants on the importance of educational standards in their teaching. "Everything has to be based on the curriculum standards," a participant asserted. Teachers reported following the standards, although with different levels of conformity. For some teachers, having defined curriculum requirements is useful for "keeping them on track." Three participants expressed the belief that standards represent a good guide and ensure that they cover the subject matter in a consistent way. One even likened the standards to a compass. On

the other hand, two participants expressed concerns about the constraints that standards posed regarding their attempts to implement an inquiry-based approach to teaching. One teacher was adamant that the advantages of following the standards outweighed the constraints they posed and it was the teacher's responsibility to apply them in an effective way. There are teachers who use the standards in a narrow way and are "too tightly into lecturing and using the textbook." There are other ways to follow the standards, as one teacher explained. For example, "one of my students created maps of the regions they are studying so that's a basic standard, it [the standard] does not give exact specifics but it gives definitely a guide."

Overall, the programs and materials designated by the standards allowed acceptable levels of freedom through multiple choices and were perceived as quite a flexible tool. One participant opined: "I follow the NC curriculum but don't think about it when I am looking for things, as long as they correspond to the curriculum. I am looking more at what my kids will be interested in." Another participant argued that you can follow the standards and still be engaging and somehow autonomous: "I don't have my kids even bring the text book to class. I am going to teach out of the text book, but I do have to follow that curriculum because of the test." Standards were seen as positive by a participant who said that "one of the good things that has come out from the testing program in the history class is that we used to have teachers stay on the Civil War for weeks, but you have to keep going." Although "sometimes the test questions can be ridiculous, there is a positive thing coming out of the standards because history teachers would teach things they liked and the kids did not get a well rounded base of field."

The N.C. Teaching Standards, derived from the National Standards for History, represent the primary educational tool for social studies and history. Two participants referred to other educational standards they also found useful in their teaching practices. Specifically, they

mentioned the NCSS Standards[42] that aim at preparing educators to teach social studies programs. One of the participants took a class where he learned how to use the NCSS and, in particular, how to integrate the ten thematic strands (see Figure X) that form the basis of NCSS. The social studies standards typically serve as a general framework to guide teachers in a field of study that is more interdisciplinary and less definite than history.

[42] Curriculum Standards for Social Studies by the National Council for the Social Studies (NCSS).

I. Culture.

II. Time, Continuity, and Change.

III. People, Places, and Environments.

IV. Individual Development and Identity.

V. Individuals, Groups, and Institutions.

VI. Power, Authority, and Governance.

VII. Production, Distribution, and Consumption.

VIII. Science, Technology, and Society.

IX. Global Connections.

X. Civic Ideals and Practices.

Figure 4.1. Ten Thematic Strands from the NCSS Curriculum Standards for Social Studies.

NCSS Standards serve as a pedagogical background for setting principles of teaching and learning objectives that go beyond the knowledge content of the field of study. As one participant commented, "if you are a good teacher, you are probably going to integrate those strands in there and the main emphasis is going to be where you can find a document or a primary source for each of those." While the pedagogical value of the standards is recognized, one participant acknowledged that they have little time to devote to them. "I sort of integrate them, but I have to get the kids ready for the end of the course test and the end of course test in U.S. History has got to go by a standard course of study for the state and not these national strands."

4.6. Standardized Testing

All six participants considered the end-of year tests to be the most constraining influence on their use of digital primary sources. The pressure of covering the standards is primarily derived from the need to prepare students for the final tests: "Quite honestly they become the guidelines for having to teach, I mean, in the testing structure, the way it is in North Carolina, you cannot deviate from the standards courses too much, so it is the driving force for how I cover my lesson." Another participant commented,

> I think that some teachers misinterpret the intent of the curriculum outline and they really start to teach to the test and I see it as a major problem in North Carolina. Everything has been score driven and the test has become the measure by which your school is judged. And I think kids are suffering in lots of schools because they are stuck to that curriculum and they are just teaching to the test.

School-based performance award programs and related final tests limit teachers' choices. The demands of covering the content that will be tested inevitably leads to a narrowing of the range of options on how a topic will be addressed. Teachers are compelled to teach students the information they need to pass the required tests and little time remains for activities that promote historical thinking. One participant stressed how disciplines other than math and reading are marginalized. This is true for history, but also for basic skills, like cursive writing. When discussing the reading of primary sources in class, the teacher revealed that students have difficulties with reading cursive, not only in old documents, but also in contemporary handwriting. She commented, "I teach 6th grade and most of these kids don't know how to write cursive, let alone read cursive and this goes back to some of these primary sources that are way back in the days… can these kids really read them?" She explained that many of her students don't know what a signature is. "I asked my kids to sign their names and they print them," she continued, "they don't know what a signature is." Even if they understand cursive, they may not be able to read antiquated script. One participant commented, "some of the handwriting is hard

to read on some of those original documents and some of these kids struggle greatly just deciphering their writing."

State tests and scores are seen as the root of the problem. According to one participant, "we as teachers have so much pressure on us because the scores reflect the teachers and if we are not teaching this material and they are not learning that, then the scores come back as if we were not doing our job." Teachers are well aware of important subjects and skills that are not imparted to students. One participant lamented: "most of our students don't get social studies until they come to middle school. They went through six plus years and most do so without even knowing anything about social studies." Another remarked about students' lack of knowledge of basic geography: "most of my kids, when I taught in 6th grade, did not know what the continents were. And this is because the most basic things are not being taught because of this test – it has just been engulfed and it is basically all math and reading. And the rest is just pushed aside."

A major problem when using text-based primary sources in the classroom is often the language of the documents. Participants pointed out that "kids have a hard time reading letters, for example, from the Civil War." They need to guide students and help translate unusual or antiquated terms. "Primary sources may look quite confusing for the students in terms of language but once they translate them into a language they understand, then they realize primary sources are not that difficult. They just have to figure out sort of the code, what that language of the 17th century would mean, e.g. a difficult word for them was *besiege*."

4.7. Search Strategies and Habits

All six participants search the web for digital primary source materials on a regular basis, from daily to once a week in preparation for each class. They all indicated the web as the main source of historical materials for their instructional practices and use Google as their primary

search service. The time devoted to web searching varied. Three participants who were currently teaching social studies, or had been in the recent past, indicated that a thorough search for primary sources would take approximately an hour of their time, especially when teaching a topic for the first time. The frequency and time dedicated to searching would also vary depending on their teaching experience. Teachers tended to select and bookmark a few preferred websites and refer to them again and again. Popular websites included American Memory,[43] DocSouth,[44] History Matters,[45] and PBS Teacher Source.[46] As one participant asserted: "in the past I would search quite often. Now that I've been teaching for around 10 years, I am familiar with the sites that I use and it is not very often that I go to a different site." Participants with longer teaching experience had often collected primary source materials that predated the web and could be printed, photocopied, and put on floppy disks. Two participants mentioned their openness to sharing their personal resources and the collaborative attitude is common among middle and high school teachers. One participant commented that one of her main sources for primary source sites was her colleagues. Not only do the teachers share primary sources, but generally they exchange lesson plans and websites, and learn from colleagues "how to make searches more effective." Collaboration is indeed encouraged by the school itself through specific meetings or team planning sessions structured by subject and grade level. These sessions were seen as opportunities to share the workload and save time.

The type of search that all participants preferred when using search engines was topic keyword. They all started their search by entering keywords related to the subject matter. Three participants noted that they sometimes entered a time period. One participant specified that he

[43] http://memory.loc.gov/ammem/index.html.

[44] http://docsouth.unc.edu/.

[45] http://historymatters.gmu.edu/.

[46] http://www.pbs.org/teachersource/soc_stud.htm.

first searched by topic, but "a lot of time I search by name, a person's name, maps and charts…for example, presidential election results maps showing which state voted which way."

They most frequently searched for pictures, sometimes daily, but less frequently for textual materials. A common way to search was through Google. "I do Google image and then I go and check if it is scholarly. I am a Google guy," one participant commented. Once again, time was a major concern: "If I had time to really dig the collection on a subject and find something that would be perfect – I have to read a lot before I get to the one most meaningful for the kids – but it is time consuming." The length of textual documents also represented a barrier for their use in the classroom: "If I use text, I cannot give an average history class a 5-page document to read. I need to give them a portion."

4.8. Searching Issues

All participants recognized that the web offers an enormous amount of primary sources, but searching the web can be a daunting experience. One participant commented that it is easy both for teachers and students to find known sources such as the Declaration of Independence; more problematic is finding "what we need, but don't know yet what it is." Searching Google or other commercial search engines could be frustrating due to the high number of results returned. As one participant commented, "because there is so much out there … you get too overwhelmed and being a teacher you are overwhelmed anyhow, so you don't want something else overwhelming you." A concern expressed by another teacher referred to the quality of the content found on the web: "you also have to make sure that things you are finding are accurate. That's important."

"Finding primary sources that I can use is not easy," one teacher observed, and "usually when I can find one that works I stick with it." Another time-related concern surrounded the time

required to select suitable materials. The typical approach that participants adopted when facing long lists of search results is summed up by this comment: "I usually look up the first few sites to see if I can find what I want. You just want what comes out to you the easiest. [But] most of the time what comes up isn't good." Two participants indicated that searching the web can become frustrating because "there is too much to choose from" and "it takes too long to search." One possible alternative is to return to the textbook, one participant observed. For example, "Glencoe"[47] may provide a good starting base. From there, the next step would be probably to go to the Library of Congress website. According to four participants, frustration occurs also when teachers use special collections of primary source materials.

4.9. The DocSouth Example

All participants had experience with DocSouth digital library at various levels, and they frequently referenced DocSouth when talking of primary source collections. While they all recognized the relevance and quality of the content of the collections, four teachers complained about access to the content. One said that if DocSouth were easier to search, she "would feel better for the quality they could use and it would be less time-consuming than Google." Another admitted that DocSouth is "kind of hard to navigate" and it requires time because "you have to wade through it." The effort required to find suitable content can sometimes be discouraging: "I was told there was an easy page that you could go to for lessons and I couldn't find it on the website." One participant was fervent in describing what teachers want when searching the web: "You click on it and it's right there as plain as day instead of having to dig and dig and dig." The level of experience and frequency of use of the website played a role in the way access was perceived. One teacher considered DocSouth very easy because, in his words, "I know exactly

[47] See Ritchie, 2001.

where I am going and I am familiar with the site and how it operates." However, one participant said DocSouth is "too scholarly for high school kids." Participants used DocSouth mostly for letters and visual information. For example, the collection of World War I posters was popular among participants and considered particularly useful.

4.10. A Case Scenario: The Great Depression

Participants discussed how they would teach and how they would search for primary sources about the Great Depression. Pictures, photographs, and journals were the types of resources participants would typically search for and use in the classroom. Visual information was the center of teaching activities for most of the teachers. One participant described a personal successful teaching activity about the Depression where students were required to make a story based on pictures: "We used all kinds of pictures, for example, the famous picture of the migrant mother with the kid.[48] Actually we went deep into that and found some history about the woman and we found the history about the person who took the picture. I said, don't you ever wonder about this person, what things would go through her head."

Participants reported using Google and Google Images to search for primary sources. Search terms varied from very general ("I would put a Google search for images, e.g., "the Depression Era," and see what comes out from there and scan through") to more domain specific ("I will type 'migration,' and then I will be more specific. You get some results, sometimes you need to narrow down"). Two participants preferred to take a more general search approach to "see what happened." Two participants gave indications of specific ways in which they would like to search: "I would do something along the line of the economic impact of the 1920s on the

[48] "Migrant Mother" by Dorothea Lange 1936: http://www.freedomvoices.org/migrant.htm.

Great Depression"; "I would search the environment from a rural perspective and a domestic perspective and I would like to see if there are any noticeable differences."

Most participants expressed a preference for formats they find easy to use, such as a picture gallery: "I like pictures in thumbnail and, if I see something that clicks with me, then I would go for it, but I would do a very broad search to begin with and see what is there."

One participant said he has collected his own materials over time ("a packet of docs for each of the New Deal programs"). Another uses a few specific websites, including the New Deal Network[49] and the Library of Congress American Memory site. He also commented that photographs in American Memory are difficult to navigate: "I don't know how they catalog them; it's kind of hard to have them collected the way I want. I'd like to do it by topics." He indicated a desire to retrieve a cluster of photographs around a theme or topic familiar to students. For example, he would like to retrieve pictures of teenagers who have run away from home. The idea of having visual information of migrant teenagers would be an effective way to "try to get them [the students] on the hook." He stressed the importance of capturing students' attention and interest with topics they can relate to: "Average teenagers don't care about history. We get them involved in the topic and this would help with their thinking process." The importance of being able to group resources (pictures, journals, etc.) around a topic that engages students was remarked upon by various participants, for example, focusing on "what kids' life was like back then, do they have running water, do they have this or that?" The importance of making comparisons that involve people of the same age was emphasized by four teachers. One stressed the fact that "teenagers don't care so much about what the government was doing; they can really get into when it is something they can relate to, for example, what teenagers were doing." Other examples included comparisons of "what life would be like for a child

[49] A website maintained by the Roosevelt Institute: http://newdeal.feri.org/.

(‘recreation, leisure time, how many months they go to school, maybe ten months and take a month off for picking tobacco’) let’s say in 1930s in Virginia or North Carolina.” One participant pointed out that there are themes in the Depression Era that can be addressed “to send them [the students] back to that time period.” Also, the theme of migration was viewed as highly suitable for comparisons: “People from farming areas going to the city looking for jobs or a comparison between North Carolina, the South, lots of people coming to the South from the North, after the Civil War, etc.”

4.11. Ideas to Improve Searching

Participants showed clear ideas about what type of search features they would like to have available. One teacher stated: “I want to be able to say, 'I want you to look at an individual who experiences the Civil War from a North Carolina perspective in 1864.' And I would like the kid to use that kind of information. I would like to be able to narrow the topic for my kids giving them a broad topic like that. I don’t know how you would call it.” Another example of search proposed by another teacher was: “I would search the environment from a rural perspective and a domestic perspective and I would like to see if there are any noticeable differences.”

The importance of gaining a general idea or an overview of the collection contents was also stressed: “I would like to see what the collection offers to me. I want to see what exactly is there.” Another comment stressed the importance of contextualization and the need to “put the place in time; this helps them [the students] to understand.” Relating topics or themes to periods and geographic locations was seen as critical by four participants. As one teacher asserted, “it is difficult to divorce [ourselves] from events; we begin with time and landmarks.” Events and decades were also seen as important ways to conceptualize periods such as the Great Depression. As one participant commented, “first I start with big topics, for example, Depression, Civil War,

colonial time in the 1600s, then I would get more specific and maybe I would put North Carolina or I would put the age of children, maybe ages eleven to thirteen in the Great Depression to put it more in the real situation for them."

When asked about geographical areas and the level of detail participants considered useful in their activities or when searching for primary sources, there was consensus that regional areas were typically used for making comparisons at the country level. The motivation was that "in U.S. History there are a lot of regional differences." Examples suggested include North against South in relation to the Civil War and Midwest versus Northeast during the Depression. In the context of North Carolina history, participants commented that searching by regions (e.g., Piedmont or the coast) would be helpful. None of the teachers were interested in a level of granularity lower than county when referring to North Carolina. As for other states or geographic regions, it would be more important to have big cities and metropolitan areas: "As far as I would go is county-wise. Coming from a rural county it is as precise as we can get. In a big town it would be different, but for me I would get at the level of the county we live in." One participant commented: "Nice to have region and the county but it is not necessary to go more specific than county level." Another believed that geographical categories should not be even as specific as "county"; "Region will be the start, then Piedmont, the Triangle, the Coast, the Mountains, but not by county."

The value of comparisons was reiterated as well: "One of the things is compare and contrast, especially with their own lives. Say they are looking at Africa, housing, or schools of Africa how they are different from their schools, for example middle school students. They need to relate to themselves if they don't they don't see the relevance." Another way to compare people that teachers considered effective is by role. One participant indicated she likes to be able

to find resources for teaching women's perspectives in history as well as to make comparisons by gender and race. She said she wants to tell a “story where the person fits in.”

In one open-ended question, the researcher asked for feedback about the idea of having an ontology to support their searches after explaining in general terms what an ontology would be. Participants were very receptive to the idea and provided suggestions about ways the tool could be helpful for them. One participant identified categories to be included referring in particular to visual information: “Topics as ways to organize pictures, then regions of North Carolina, and then certain years.” Another suggested that primary sources should be searchable by categories that take into consideration their ultimate audience: middle school and high school students. These categories should enable the retrieval of readings that are appropriate for the level of those students. One teacher commented on the importance of relating the ontology to the curriculum. Although he took a fluid approach to the use of the standards, he recognized that topic access would be most useful if it followed the curriculum:

> I would not look in this way, but if it has to do with finding things that are going [along] with your teaching standards, it will be topical because, for example, for US history the standards basically go through progression [?] so you have to understand, for instance, the foundation of government. So I think that actually would be helpful.

4.12. Main Findings from the Interviews

The interviews offered a clear view of the types of resources social studies teachers need, what they are able to find and not find, and what they would like to find. Their comments were informative on how primary sources could be integrated into the classroom and revealing on the strategies they adopt to apply current pedagogical principles to cope with institutional constraints. Although limited in scope, the responses from the six participants confirmed several of the same points and conclusions drawn from the literature:

- Teachers have a positive attitude about technology and are habitual users of the Internet. They use digital resources and value the benefits of primary sources for teaching history according to current pedagogical principles.
- They need to save time and quickly find what they need for the class. They find the search services they typically use unsatisfactory, including commercial search engines and library catalogs. Commercial search engines return overwhelming lists of results and little functionality to narrow them down to select reputable resources. Special digital collections are often hard to use.
- Curriculum standards represent the context for planning and instruction as well as the sources from where they derive guidance for the discipline content they need to cover and for the pedagogical approach to the subject matter.
- Performance-award programs and related high-stakes tests significantly limit the time they can dedicate to foster inquiry-based learning and even to fully address the standard course of study.
- Visual materials are preferred over textual as a powerful means to engage students.
- Teachers consider topicality a primary aspect to search and select results relevant to them.
- For teaching history in ways that promote critical thinking, it is important to compare and contrast resources, ideas, people, and institutions.
- It is critical for teachers to contextualize the content they present. They find it useful to compare and contrast through time and space.

- A good strategy to keep students engaged is by making connections between students' lives and the lives of people from the past. For example, students relate more easily to teenagers from another time.

Because of the small study sample, the findings reported here cannot be generalized to the social studies teacher population as a whole. Moreover, all of the participants had experience using digital materials in their classes, and had a shared belief in their value. Despite the homogeneity of the participants, this study does shed light on the broader context that surrounds and informs social studies teachers' practices including seeking information for instruction. User studies often underestimate the importance of context when investigating users' needs and wants (Afzal, 2006). If context is considered, it is often from a simple, one-dimensional perspective, without recognition of the true complexity of context (Carr, 2006). This study revealed that teachers operate in a landscape where factors such as instructional practices, personal teaching styles, pedagogical principles, curriculum standards, and information sources shape and constrain the way they search and use digital library content for instruction. This instructional context helped identify instructional scenarios and tasks or activities where an ontology would help the seeking process and add value to the search system.

Teachers' input was utilized to inform the ontology design process when decisions had to be made about how to model the domain knowledge of the collection. One of the main tenets that emerged from the user study is that people, time, space, and domain-specific concepts are central aspects in teaching history. These findings align with the results of Tibbo's study (1989) indicating that: "historians use these facets [time, place, and topics] to delimit their research, classify their literature, and organize college curricula" (p. 591) and they should be main points to be included in abstracts of historical literature. These dimensions served to shape the

conceptual structure of the ontology. They were translated into a core of upper-level categories that provided the foundation for the ontology knowledge framework as discussed in the next chapter.

CHAPTER 5

PHASE II ONTOLOGY DEVELOPMENT

5.1. Methodology

Building ontologies for information systems "remains an arcane art form" (Guarino & Welty, 2002, p. 61), and regardless of the plethora of definitions, "one must actually do ontology to understand what it is" (Welty, 2003, p. 11).

One of the greatest challenges in constructing an ontology is the scarcity of standard methodologies. As Ceusters, Smith, and Goldberg (2005) point out, there are no ISO standards for ontology development yet. Ontological engineering, the discipline applied to ontology development and its use, is relatively young, especially when compared to more established fields such as software engineering or knowledge engineering (Fernandez-Lopez, 1999). As a result, ontological engineering does not rely yet on an established set of methodologies that are based on consensual principles. In recent years, an increasing number of studies have focused on methodological issues (Bouaud, Bachimont, Charlet, & Zweigenbaum, 1995; Gruber, 1993; Mizoguchi et al., 1995; Noy & Hafner, 1997; Noy & McGuinness, 2001; Uschold, 1996; Uschold & Gruninger, 1996). Some of these studies attempted to define principles that would systematically guide the development of ontologies. Others, such as Fernandez-Lopez (1999) and Corcho, Fernandez-Lopez, and Gomez-Perez (2003), offer extensive overviews of methodologies for ontology construction and still others, like Beck and Pinto (2002) and Pinto

and Martins (2004), analyze and compare the most representative methodologies, techniques, and guidelines for building ontologies.

One of the most comprehensive and well-established methodological frameworks used for constructing ontologies is METHONTOLOGY, which was developed by the Laboratory of Artificial Intelligence of the Polytechnic University of Madrid (Fernandez-Lopez, Gomez-Perez, & Juristo, 1997). METHONTOLOGY offers a general framework that defines design criteria, practices, activities, and tools for ontology engineering. It is based on real-world experience for building ontologies in the chemical domain and is inspired by knowledge engineering techniques. METHONTOLOGY proposes a waterfall process, which is typical of software development, and identifies a series of activities required for constructing and maintaining ontologies that encompass the entire lifecycle of the ontology. These activities include: specification, knowledge acquisition, conceptualization, formalization, integration, implementation, evaluation, documentation, and maintenance. For these reasons, METHONTOLOGY is used as a model for the present study. The development of the TBS Ontology addressed in this study will end at the conceptualization stage and what follows is a brief description of the activities involved in this process.

5.2. Development Activities

5.2.1. Specification

The specification phase includes the definition of the purpose and the scope of the ontology. As Devedžić (2002) points out, the general purpose of developing an ontology is "to clarify the domain's structure of knowledge and to enable knowledge sharing and reuse." A more specific objective when constructing an ontology is to represent "consensus knowledge of a

community of people" (p. 143). This tenet is shared by Mizoguchi (2003) who argues: "…an ontology should be shared by many people in nature. If it is not shared by a community, it loses its utility. As a condition to reach such a goal "an ontology should be designed collaboratively, with a happy agreement on its development in a community" (p. 373). The importance of community involvement in the development process has been highlighted as one of the elements of the success of the Gene Ontology (GO) that "was originated from within the biological community rather than being created and subsequently imposed by external knowledge engineers" (Bada et al., 2004). The authors stress the importance of consulting with members of the community for developing a model of a domain that "is more likely to conform to the shared view of a community."

However, a user-centered design approach is not common in ontology development. While this approach is broadly adopted in system development as a strategy to improve system usefulness and usability and overcome the limitations of traditional system-centered design (Gould, Boies, & Lewis, 1991; Mao, Vredenburg, Smith, & Carey, 2005), the conventional model of ontology design and construction is primarily system-oriented. Typically, ontologies are built by knowledge engineers who make their own interpretations of the knowledge to be formalized. Domain experts may be involved in the process, but real end users are typically excluded from the entire lifecycle of ontology development. Development methods that target end users are not common and there are few studies that address this approach. One of these studies is proposed by Holsapple and Joshi (2002), who discuss a collaborative approach to ontology-building based on the Delphi method where the ontology is a result of "a joint effort of people's experiences and points of view" (p. 44).

For this study, a user-centered approach was adopted to ontology development. The rationale for a user-centered approach was to better capture, model, and validate the "consensus

knowledge of a community of peoples" as discussed earlier. As Gruber (2004) asserts, "every ontology is a treaty – a social agreement – among people with some common motive in sharing" (p. 5). In the context of the TBS Ontology developed in this study, the agreement or, more specifically, the ontological commitment, was built by factoring in the end users' viewpoints in a participatory way.

As described in chapter 4, it was users who provided the basis for understanding whether and how an ontology could be helpful to teachers, as well as what requirements should be included for the ontology to be valuable. As discussed in Chapter 6, end users were also involved in evaluating the TBS Ontology.

5.2.1.1. Purpose

The overall goal of the TBS Ontology is to facilitate access to and ultimately the use of the TBS learning object collection. One way the ontology can improve access is by semantically enhancing the annotation of the digital content of the objects. To this end, the primary purpose of the TBS ontology is to serve as an indexing tool to support semantic markup of the TBS learning objects. The nature of ontological semantics is declarative and thus not tied to specific applications. This makes such semantics available for advanced applications, in addition to the support for semantic markup. Possible additional applications of the TBS Ontology would include, for instance, concept extraction to complement and enhance annotation-based retrieval. Also, the TBS Ontology could be employed for faceted search applications to improve navigation and searching functionality of the collection.

5.2.1.2. Scope

The scope of the TBS Ontology is primarily the knowledge domain or subject matter covered by the TBS collection of learning objects. The TBS Ontology is domain-specific, as domain ontologies are viewed as suitable sources of semantics for describing web resource content. In fact, ontologies "provide vocabularies about concepts within a domain and their relationships, about the activities taking place in that domain, and about the theories and elementary principles governing that domain" (Gomez-Perez et al., 2004, p. 33).

In ontological engineering, one of the methods for defining the scope of the ontology is based on the use of competency questions which should be formulated in relation to the ontology application scenario (Gruninger & Fox, 1995). Competency questions created in the initial stages of the ontology-building process are utilized as benchmarks to test the efficacy of the ontology in providing satisfying answers. Such a test is intended to verify whether the ontology contains a necessary and sufficient set of axioms to represent and solve competency questions (Gruninger & Fox, 1994). Competency questions can also be informal and intended to be answered by the ontology on the basis of motivating scenarios (Pinto & Martins, 2004). As Noy and McGuinness (2001) explain, competency questions formulated at the beginning of the development process do not need to be exhaustive but they are drawn to help reflect on whether the ontology contains enough information to answer these types of questions and whether the answers require a particular level of detail or representation of a particular area.

In the context of this study, informal competency questions and motivating scenarios were derived from teachers' real-world examples as described during the in-depth interviews discussed in Chapter 4. They were also informed by the North Carolina Standard Course of Study. These questions served to frame the subject domain in the early stages of development of

the TBS Ontology. They were later adopted as task questions within the ontology evaluation in Phase III of the study, as discussed in Chapter 6.

5.2.2. Knowledge Acquisition

Knowledge acquisition refers to the act of collecting knowledge and capturing the domain of interest. Knowledge acquisition accompanies the ontological engineering process throughout the life cycle of the ontology, although it tends to decrease in importance as the process advances (Fernandez-Lopez et al., 1997).

The importance of knowledge reuse is well recognized by ontology developers and the need to construct libraries of ontologies that can be reused and adapted to different domains and classes of problems have been emphasized by many researchers (Uschold & Gruninger, 1996). Noy and McGuinness (2001), for example, recommend considering existing ontologies in the same or similar domain when starting the process of knowledge acquisition to maximize the reuse of semantics. Methods of reusing previous ontological knowledge include ontology *merging*, where an ontology is augmented by incorporating selected parts from other ontologies, and ontology *translation*, which makes use of ontologies developed independently (Dou, McDermott, & Qi, 2003; Corcho & Gomez-Perez, 2005). Both approaches face serious technical challenges posed by the complexity of resolving expressive, stylistic, and organizational differences. Ontologies can also be built by extraction from larger ontology corpora such as SENSUS[50] and WordNet[51] (Swartout, Patil, Knight, & Russ, 1996). Again, the difficulty of performing knowledge alignment and reconciliation and the lack of methods and suitable tools to

[50] http://www.isi.edu/natural-language/projects/ONTOLOGIES.html.

[51] http://www.cogsci.princeton.edu/~wn/.

overcome heterogeneity make it difficult and costly to take advantage of their capital of knowledge (Hameed, Preece, & Sleeman, 2004).

Manual knowledge acquisition is labor intensive, and it is at the origin of the "knowledge engineering bottleneck," a well-known problem identified in the mid-1980s in expert systems development (Maedche & Staab, 2004). On the other hand, automatic techniques have been developed that generate ontologies from text to ease the process of constructing ontologies. "Ontology learning" is the process of generating ontologies from text which combines knowledge acquisition based on machine-learning techniques with modeling tasks (e.g., import, extraction, pruning, and refining) performed by humans. Although cost-effective for large-scale ontologies, automatic or semi-automatic techniques are still in experimental phases and are prone to errors (Lim, Song, & Lee, 2004). Moreover, knowledge acquisition based on statistical techniques is not effective for collections containing a high percentage of non-textual materials.

In the context of the TBS Ontology, knowledge acquisition was performed manually due to the small size of the ontology prototype and the amount of relevant non-textual content present in the collection. Knowledge acquisition was carried out through document and text analysis of the target collection and through knowledge elicitation from the interviews with teachers discussed in Chapter 4. The textual content of the learning objects provided the main set of concepts of the domain. Background knowledge was derived from the Virginia-Carolina Service Corporation's report – an extensive report on tobacco stringing operations in North Carolina and Virginia written between 1938 and 1939. This document contains descriptions and photographs of the families that relied on tobacco stringing labor in Wilkes County and Reidsville, North Carolina, and Richmond and South Richmond, Virginia, and provided the basis for the TBS learning objects.[52]

[52] http://www.lib.unc.edu/ncc/tbs/report.html.

Reuse of existing knowledge from domain ontologies was limited due to lack of suitable sources. While the number of ontologies in electronic form, as well as the services to facilitate the discovery of web-based ontologies,[53] is continuously growing, ontologies available in the domain of U.S. History and cultural heritage in general are very few (Nagypal, Deswarte, & Oosthoek, 2005). One example of a history ontology is under development within VICODI, a European project with the goal of providing a new visualization and contextualization system for digital content.[54] The VICODI ontology is an ongoing project and its focus is on areas of history that are tangential to those addressed in this study. In a broader context, there is a groundswell of support to adopt a semantic approach to the search and navigation of cultural heritage information (DigiCULT Report, 2003; Gill, 2004; Veltman, 2004). One of the most mature initiatives is represented by CIDOC Conceptual Reference Model (CRM), a core ontology expressing upper-level concepts common across cultural heritage documentation (Crofts, Doerr, Gill, Stead, & Stiff, 2005). Developed within the museum community, CIDOC CRM has the broader goal to enable semantically-rich information exchange between museums, libraries and archives (Gill, 2004). Although not a direct source of knowledge for the TBS Ontology, CIDOC CRM is viewed as an appropriate overarching framework where a full-fledged TBS Ontology could be linked and related to other germane domain-specific ontologies.

Several knowledge organization systems were consulted in developing the TBS Ontology including WordNet and the Getty Thesaurus of Geographic Names (TGN).[55] Lexical resources like WordNet can be very helpful in capturing the nuances of the language, providing both generality and consistency (Guarino, 1997b), and WordNet has indeed proven to be a useful

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[53] Examples of online ontologies libraries include: *Ontolingua Server* (http://ontolingua.stanford.edu), and *DAML Ontology Library* (http://www.daml.org/ontologies/keyword.html).

[54] www.vicodi.org.

[55] http://www.getty.edu/research/conducting_research/vocabularies/tgn/.

reference tool for suggesting concepts to be manually incorporated and to help frame the ontology structure. The TGN has also provided a useful reference tool for standardized placenames in the geospatial segment of the ontology. Reference materials relevant to the field of history were utilized for gathering background and domain-specific terminology, including the *Encyclopedia of Southern Culture* (Wilson & Ferris, 1989), which focuses on the American South. Terms and concepts were also derived from the history textbook *American History: The Modern Era Since 1865 (*Ritchie, 2001)[56], history web sites (e.g., The New Deal Network[57]), and lesson plans from educational web sites (e.g., LEARN NC[58]) suggested by interviewees and faculty at the UNC School of Education.

5.2.2.1. Knowledge Elicitation

Knowledge elicitation is part of the knowledge acquisition process and is commonly performed with the involvement of experts in the domain being modeled. In this study, middle and high school teachers were an important source of vocabulary and concepts. Although interviewing teachers was not primarily intended for knowledge elicitation, their description of their information searching and seeking practices and teaching scenarios were an invaluable source of knowledge for the development of the ontology in a number of ways. For example, teachers indicated clusters of domain concepts and themes they consider essential or useful in teaching U.S. History and the Great Depression (e.g., what was it like to attend school in N.C. during the Great Depression?). They offered input on areas of knowledge domain and perspectives they find important when delivering instruction. As discussed earlier, ontology

[56] Textbook currently used in North Carolina schools.

[57] This is an educational guide to the Great Depression sponsored by the Franklin and Eleanor Roosevelt Institute at http://newdeal.feri.org/.

[58] http://www.learnnc.org/.

upper-level categories, including people, time, space, and domain-specific concepts, emerged as essential perspectives to represent the content they need to cover in their teaching. Teachers' descriptions of their instructional methods and practices offered suggestions on candidate properties to be associated with concepts and on potentially useful ways to link the concepts. For example, they indicated the importance of contextualizing content and of comparing and contrasting resources as part of their pedagogy. Also, teachers gave specific guidance on the desirable level of granularity for specific areas of knowledge (e.g., for geospatial concepts, they indicated "county" as the most specific level for which they would search).

The outcome of the knowledge acquisition process, including the knowledge elicitation phase, was a list of concepts/terms with candidate relations and properties (see Appendix IV). Once the terms were identified, the next step was to address the conceptualization underlying the terms.

5.2.3 Conceptualization

This phase involves capturing the conceptual structure of the ontology by defining concepts and their properties and relationships. After acquiring the vocabulary, the unstructured knowledge needs to be organized through the analysis of the conceptualization underlying the glossary terms and the development of class hierarchies. As Noy and McGuinness (2001) explain, class hierarchies can be developed *bottom-up* by moving up toward generalization or *top-down* by moving down toward specialization. The top-down approach is typical of constructing formal ontologies. The bottom-up approach is usually adopted when ontologies are built by extraction from a knowledge base (e.g., KACTUS project (Schreiber, Wielinga, Jansweijer, Anjewierden, & van Harmelen, 1995)). In general, computer science ontologies are built bottom-up by defining the data structure of individual applications and then progressively

merging them with higher level concepts. A third way is represented by the *middle-out* approach that combines top-down and bottom-up methods. The middle-out approach helps to determine a balanced level of detail, facilitates the understanding of commonality between concepts, and also reduces the risk of "inconsistencies" and the likelihood that the ontology will need to be revised (Uschold & Gruninger, 1996). Noy and McGuinness (2001) present another strong argument in support of the middle-out approach. They assert that the middle-out strategy is usually easier because, according to the categorization theory of Rosch (1978), the concepts in the middle are generally the most descriptive within a universe of discourse. For the TBS Ontology, the middle-out method has been adopted whenever possible.

Conceptualization is considered to be one of the most difficult activities in ontology design because it involves not only a subjective representation of the world, but "the representation of how people see this world and how they categorize things in their minds" (Noy, 1997, p. 18). There are a variety of ways ontologies may represent a domain and choosing from this range of options has significant implications for ontology development. Indeed, the task influences what knowledge is represented and how it is represented. Moreover, modeling knowledge entails selecting portions of reality relevant to the tasks to be performed (Devedžić, 2002).

The domain of interest addressed in this study is itself challenging. In fact, the subject domain of history and cultural heritage in general has scarcely been explored in ontology research. Constructing historical meaning can be challenging because of the nature of the subject matter. Modeling a domain of history, as well as of most disciplines in the humanities, poses several challenges. First, history does not rely on a tradition of structured terminology and rigorous classification as do most scientific disciplines. Fields such as medicine, biology, engineering, but also business and e-commerce, can rely on rather accurate and stable

vocabularies. Some of these domains, notably biology, have been systematically classified and their semantics are now specified in a number of well-known ontologies (e.g., Galen for medicine,[59] Gene Ontology (GO)[60] for bioinformatics, and EngMath[61] for engineering). As Brewster et al. (2004) point out, some types of knowledge "are extremely suited to ontological representation, such as taxonomic information, but this is not always the case" (p. 72).

Also, if compared to physical science domains, history presents a highly interpretative nature populated with concepts that are often complex, abstract, and open to a range of different and even conflicting definitions. In the context of the TBS Ontology development, understanding the community of users the ontology is going to serve and the functionality that is going to be supported has greatly assisted in making modeling choices that capture common and shared meaning of the domain of interest. Identifying the kinds of objects and relations that can exist in the domain requires careful analysis (Chandrasekaran, Josephson, & Benjamins, 1998). Concepts and semantic relationships are not given a priori and they are not neutral, but instead they are the result of complex interactions within a discourse community. As Talja (1997) argues: "Knowledge and knowledge structures are neither objective nor subjective, but intersubjective, produced within a shared system of meanings" (p. 73).

Just as different languages may be used to describe reality, different ontologies may be used to describe a given domain of interest. Tasks influence what knowledge is represented and how it is represented. As with any other model, ontologies represent specific aspects of a domain of interest and the ontology designer selects those aspects relevant to the tasks to be performed (Devedžić, 2002). The approach to domain conceptualization adopted in this study takes into

[59] http://www.openclinical.org/prj_galen.html.

[60] http://www.geneontology.org/.

[61] http://www-ksl.stanford.edu/knowledge-sharing/papers/engmath-tree.html.

account user factors that contribute to building "a shared system of meanings," including how this domain content is interpreted and used by teachers and what types of tasks the ontology tool needs to support.

Conceptualization organizes and structures the acquired knowledge using external representations that are independent of the implementation languages and environments. Indeed, conceptualization must be performed at the knowledge level, as argued by Newell (1982), and should be independent from the symbol-level, such as a specific encoding (Gomez-Perez et al., 2004). Skuce (1995) suggests the conceptualization process should be represented in an intermediate format more formal than natural language, but not completely formalized. This intermediate representation can be based on tabular or graphical notations: "Specifically, this phase organizes and converts an *informally* perceived view of a domain into a *semiformal* specification, using a set of intermediate representations that the domain expert and ontologists can understand" (Fernandez-Lopez, Gomez-Perez, Sierra, & Sierra, 1999, p.39). A common means to represent ontologies at the conceptualization level is by using hierarchical modeling and graphs to visually represent the model of the target world (Devedžić, 2002). In the context of this study, the TBS Ontology model has been visualized through concept maps that provide a rather clear and intuitive technique for displaying knowledge models. The concept models were developed using Cmap Tools software.[62]

The list of terms collected during the knowledge acquisition phase provided the basis for the conceptualization. These terms were analyzed, converted into concepts, and clustered in four upper-level categories: Time, Domain Concepts, People, and Space. These four categories emerged from the interviews with teachers (see Chapter 4) and served as a framework to aggregate the terms and organize the concepts to develop the conceptual structure of the

[62] Cmap Tools is a software product developed by the Institute for Human and Machine Cognition (IHMC) and freely available for educational use (http://cmap.ihmc.us/).

ontology. As it turned out, these upper-level categories tied in nicely with some of the NCSS thematic strands and have been associated with the appropriate clusters of concepts on the concept maps:

1. Time relates to NCSS II. Time, Continuity, and Change and NCSS VI. Power, Authority, and Governance.

2. Domain Concepts relate to NCSS VII. Production, Distribution, and Consumption and NCSS VIII. Science, Technology, and Consumption.

3. People relates to NCSS V. Individual, Groups, and Institutions.

4. Space relates to NCSS III. People, Place, and Environments.

The concept maps annotated with the relevant thematic standards are displayed in Appendices V-IX.

5.2.3.1. Domain Concepts

Domain-specific concepts were derived primarily from the subject matter of the TBS learning objects. As discussed earlier, the collection illustrates various aspects of living conditions of home workers in the late 1930s in rural areas of North Carolina and Virginia and provides a remarkable source for understanding the economics of these areas. From the content analysis of the objects a few families of concepts were identified that include domestic life, labor status, family budget, home conditions, etc.

Such aspects were, by-and-large, aligned with the strands of themes from the National Council for the Social Studies (1994) that address similar perspectives (e.g., farm life, home life, medical care, etc.). NCSS thematic strands have been associated, whenever appropriate, with the respective families of concepts. They were displayed on the concept maps as a visual device to help the teachers identify familiar instructional themes. Moreover, the N.C. standard course of

study contributed discipline knowledge from which additional concepts were derived in order to consolidate and broaden, when needed, the semantic coverage of the domain. In addition, concepts and additional themes were drawn from teachers' interviews that further consolidated the knowledge collected and provided some useful suggestions to be included in the ontology (i.e., Education: "How long students would go to school back then?").

Domain concepts were sometimes ambiguous and open to a spectrum of modeling possibilities. For example, poverty was an important concept in the context of the domain being model and it was also a challenge in terms of definition. In fact, the notion of poverty is prone to changes. For example, in the 1930s the definition of needs used to compute poverty thresholds was broadened. Franklin Delano Roosevelt himself defined basic needs as "the opportunity to better one's life, as well as the more usual resources for food, housing and shelter" (U.S. Department of Health, Education, and Welfare, 1976, p. 6). Moreover, the poverty threshold's definitions were not developed by the federal government until 1963-1964. In the context of this study, a definition for "poverty level" was created based on historical data on income taken from the *Historical Statistics of the United States* (Carter, 2006). A concept map representing the category of domain-specific concepts is provided in Appendix VI and Appendix VII.

5.2.3.2. People

As discussed in Chapter 4, "people" was identified as a central category for the teaching of history. The relevance of this category was noted frequently during the interviews for its pedagogical value in relating students with life histories from the past. The importance of personal relations, in particular familial and social relationships, to support teaching activities such as comparisons of personal narratives and reconstruction of social identities has been

discussed (Pattuelli & Norberg, 2006). The category of "people" is included as one of the ten thematic strands identified by the NCSS to guide social studies instruction. Specifically, the 5th NCSS Thematic Strand is entitled Individual, Groups, and Institutions and stresses the importance for human beings "to understand historical roots and to locate themselves in time" (National Council for the Social Studies, 1994). People are a central component of the TBS collection that includes the description and photographs of home-based workers, and instances of this category will populate the ontology as its development progresses.

How modeling human entities can be exploited for semantic web applications is shown by the Friend-of-a-Friend (FOAF) project.[63] FOAF is a lightweight ontology and semantic web application intended to describe people with an emphasis on their personal web-related properties (email, homepage, etc.) in order to create a social network environment. While FOAF is an interesting source of inspiration, the representation requirements of people from the past pose a different order of modeling issues. As Guarino (1998b) shows as a case of inappropriate use of the subsumption relation, a human who loses her or his existence cannot still be an instance of human, while their body still exists as a physical object. To avoid problems with multiple inheritances, the author suggests addressing the instance of extinction in a dual mode: "human body" as a subclass of "physical object" on one hand, and as part of "human" defined as subclass of "living thing." Mizoguchi (2004) supports this modeling solution since, "A human is heavily dependent on the body, but its identity comes not from the body but from the mind" (p. 195-196). Indeed, complex philosophical implications are at the basis of modeling choices of this nature and have to do with how the identity of the humans is interpreted. Figure 5.1 shows a tree-based representation of the category of "people" used in the TBS ontology. A concept map of this category is provided in Appendix VIII.

[63] http://www.foaf-project.org/.

```
Physical Object
Human body
Person
  age
  birth_date
  death_date
  child(Person:"parent", Person:"child") (range: 0-12)
  adolescent (range: 13-19)
  adult(range: 20-65)
  senior(range: >66)
  father(Person:"child", Person:"father")
    mincardinality: at least one child
  friend(Person, Person) symmetric
  lives(Person, Place)
  member(Social Group, Person; Family, Person)
  mother(Person:"child", Person:"mother")
    mincardinality: at least one child
  name(string)
  parent(Person:"child", Person:"parent")
  sex(Person, constant: female, male) - inverse
  sibling(Person, Person) – symmetric
  spouse(Person, Person) –  symmetric
  occupation(Person, Job)
  work status (employed, unemployed)
  social status (Person, Upper/Middle/Lower Class)
  marital status (Person, Married, Non married, Divorced, Widow)
```

Figure 5.1. Tree-based representation of the category of "people."

5.2.3.3. Time

Temporal dimensions are notoriously challenging to model and temporal reasoning is largely an open issue. A good deal of research has been produced in this area that is mostly theoretical (Hayes, 1985a) and primarily rooted in philosophy (Mani, Pustejovsky, & Gaizauskas, 2005). Considerable research in artificial intelligence and computational linguistics has been focused on the use of linguistic means to represent and situate events in time. For example, research on annotation of temporal information in large textual corpora has resulted in the development of TimeML, a standard for a specification language for events and temporal

expressions and their orderings (Pustejovsky et al., 2003). Investigations have just begun in this area of research and research has also taken place in the semantic web community focusing on the creation of OWL-Time[64], an ontology of time intended to express the temporal content of websites and the temporal properties of web services. OWL-Time addresses complex temporal concepts and properties including measures of duration, representation of frequency, and temporal units such as the calendar and the clock. Still under development, the purpose of this ontology is to enable reasoning about temporal aspects of web contents (Hobbes & Pan, 2004). At this time, more research is needed to be able to express temporal constructs in a web-based working program that allows advanced temporal reasoning. Although promising for the development of temporal analysis and temporal annotation, these ideas are far beyond the requirements of the ontology as they emerged in this study.

It is almost axiomatic to recognize that temporal entities are foundational in history: "The study of history places human beings and their activities in time" (N.C. Social Study Standard Course of Study, 2006).[65] Temporal as well as spatial annotations enable contextualization of content that is one of the tasks that teachers indicated as important for their searching and teaching. The relevance of context in relation to historical documents, and visual resources in particular, is highlighted by Lanzi and Besser (1998), "Deprivation of meaning that images 'undergo' when they lack contextual information [is one of the most] compelling and complex aspects of cultural heritage" and can make the images become 'silent'" (p. 4). In the case of the TBS learning objects, where images are a considerable part of the content, temporal annotation would provide an essential means for enhanced retrieval.

[64] http://www.isi.edu/~pan/OWL-Time.html.

[65] http://www.ncpublicschools.org/curriculum/socialstudies/scos/2003-04/007history.

Expression of temporal aspects of content is open to a wide range of modeling choices (e.g., measures of duration, calendar dates, frequencies, concatenation of temporal intervals, etc.) and the tasks the ontology needs to support have guided modeling decisions when this was appropriate. The analysis of the domain knowledge covered by the TBS collection and the understanding of the instructional needs expressed by the teachers suggested that the temporal dimension can be effectively represented through core temporal entities that include "historical period" and "date." "Historical period" such as Reconstruction represents the knowledge unit for modeling the periodization of U.S. History as prescribed by the curriculum and universally adopted in history instruction. Another core entity included in the TBS Ontology is "event"[66] which pertains both to the time and the space conceptual dimension. Each event can express a `has_sub-event` relationship with any number of other events.

As discussed earlier, teachers would benefit from the possibility of finding resources contextualized in time and related to historical periods appropriate for instruction. Also, finding materials that allow them to compare and contrast primary sources through time as well as through space was as an important task for teachers to perform in their classroom activities. To this end, a set of relations have been identified that may facilitate these tasks. They express initiation and termination (`begin/end`) to specify time intervals, concurrence (`during`), simultaneity or punctual coincidence (`when`), and sequence (`before/after`). These relations would enable temporal ordering of events as well as content aggregation according to the dimension of time. The concept model of this category is presented in Appendix V.

[66] "*Events* are types of entities which represent occurrences in space and time (e.g., car accident or a business meeting)" (Perry, Sheth, & Arpinar, 2006, p. 7).

5.2.3.4. Space

The use of ontologies for geospatial applications is a rather new research topic within the ontology research community. The conceptualization of spatial entities raises complex formal ontological questions about the nature of spatial dimensionality. The notion of discrete and continuum in relation to physical space and the notion of boundaries and holes are among the controversial issues being discussed (Casati & Varzi, 1994). For example, Smith and Varzi (2000) analyze differences in spatial boundaries and propose to distinguish between *bona fide* and *fiat objects*. While *bona fide* boundaries refer to the physical world (e.g., islands), *fiat* boundaries are instead the result of human demarcation resulting from political or legal decisions (e.g., national borders). Therefore, *fiat* objects are the ones that typically populate the geographic domain (Smith & Varzi, 2000).

Spatial information can be addressed from a wide range of approaches that directly impact the types of information that can be discovered. For example, spatial features such as place, orientation, and mathematical coordinates (e.g., latitude and longitude) would allow answering questions about direction or the distance of a place from another. However, spatial reasoning is no less challenging than temporal reasoning when it comes to practical applications. The development of standards and good practices for representing geospatial semantics and implementing ontology-based geographic applications has just begun to be addressed (Rodríguez, Cruz, Egenhofer, & Levashkin, 2005).

In the context of the TBS Ontology, task requirements identified from the user study provided the main rationale for how to model spatial data in ways that enable useful query capabilities. As discussed earlier, teachers were concerned with the lack of geographic precision

when accessing resources via named places.[67] Also, they highlighted the need to contextualize as well as to compare and contrast historical information through space in addition to time (e.g., "North vs. South during industrialization").

Limitations of spatial indexing and geographical access to library resources have been discussed in the past (Buckland, 2004). For example, Fraser and Gluck (1999) point out that, in current descriptive practices, geospatial metadata lacks "scalability of detail" which is important for enabling users to "quickly access greater or lesser degrees of detail as desired" (p. 28).

In the TBS Ontology, geospatial information has been modeled primarily, but not exclusively, in the form of administrative entities (e.g., nations, regions, states, etc.) rather than physical entities (mountains, oceans, rivers, etc.).[68] These types of entities refer to places defined by administrative boundaries and conditions that would be defined as *fiat* objects in the context of formal ontology. Administrative entities include political subdivisions (e.g., state, province, county); municipalities (e.g., city, town, village); residences and street addresses and other types of entities (e.g., Indian reservation). Interviews and content analysis of TBS documents suggested the types of spatial entities for the TBS Ontology showed in Figure 5.2.

```
Country
-Regional Area
-State
--State Region
---County
----City
```

Figure 5.2. Tree-based representation of the category of "space."

[67] "Named Places are those entities with static spatial properties and clear spatial extents (e.g. a manufacturing plant, an apartment building, a city, etc.)" (Perry et al., 2006, p. 7).
[68] For example, the concept of "river" was included.

As suggested by several teacher participants in the user study, the specification of areas at the county level as well as at the state level are essential in their teaching practices. They typically address topics and events by relating them by regional areas (e.g., the Great Depression in the Midwest and in the South). While "county" was identified as the lowest granular level of detail useful for their queries, "city" was also added to represent the domain knowledge of the collection in a comprehensive way (e.g., resources related to Richmond were included in the collection).

One of the challenges in representing spatial concepts is the use of name descriptors. Geopolitical entities as well as geographical places do change over time and they can be known by different names. The Getty Thesaurus of Geographic Names (TGN)[69] has been the reference tool for this portion of the ontology and served as placename authority file. Ontologies are defined at the knowledge level (Newell, 1982) and do not typically include lexical functionality. Yet, embedding a lexical tool such as the TGN in the ontology would provide a useful enhancement to the vocabulary. Currently, ontology development tools, including Protégé, do not provide terminology support. However, the need for ontology management tools to support term reconciliation has been recognized and this functionality may soon be added to major ontology editors.

These geospatial concepts are organized in a tree structure that, unlike the taxonomic structure of subsumption, does not support strict control of inheritance (Kwaśnik, 1999). The relationships between these concepts are instead partitive (e.g., "Piedmont" `part_of` "North Carolina"). Parthood relations are fundamental structuring primitives (Noy & Hafner, 1997). They are also problematic relationships because of the variety of different types that exist and the relative implications for dependency (Winston, Chaffin, & Herrmann, 1987; Keet, 2006). For

[69] http://www.getty.edu/research/conducting_research/vocabularies/tgn/index.html.

relating concepts spatially in the TBS Ontology, the variants `contained_in` and `located_in` have been adopted to express the meaning of containment and location. These partitive relations are of the type "place-area"[70]; they enable aggregation by composition and hold transitivity. As Keet (2006) suggests, they can be subsumed by both `part_of` and `spatial_part_of` to ensure consistency. Another topological relationship included in the TBS Ontology is sequential or adjacency: `adjacent_to` (e.g., North Carolina adjacent_to Virginia).

Reasoning over parthood is difficult to perform. However, partition can be addressed in terms of transitivity that is held by the set of spatial relations included in the TBS Ontology. This functionality may help find materials by logically expanding or refining queries without the need to rely on syntactic matching of geographic descriptors. Also, leveraging topological relationships of this type may facilitate tasks of content contextualization and geopolitical comparisons which represent important tasks for teachers to perform. Also, it is worth mentioning the role the ontology may play in semantic disambiguation, as in the case of a placename that does not have unique identification, for example Venice in Italy and Venice in Florida, or in the context of the TBS Ontology, Columbus (county in North Carolina) and Columbus (town in Ohio).

Geared specifically to the scope of the TBS Ontology, the model can be viewed as a basic knowledge structure suitable to be expanded to incorporate additional ontological constructs as the ontology progresses in the future. A conceptual model of the spatial knowledge of the TBS Ontology is provided in Appendix IX.

[70] Part-place cannot be separate from the whole-area (Odell, 1998).

5.2.3.5. Concluding Remarks

The final outcome of the conceptualization activity was a series of five concept maps (see Appendices V-IX) that altogether correspond to the TBS Ontology model. This ontology model is in the form of a prototype and further consolidation and refinements are expected to be carried out based on the results of the evaluation study. To emphasize the function of "*seeding* the collaborative design activity" (Holsapple & Joshi, 2002, p. 46), the ontology model is also identified as a *seed ontology* that covers the expected scope of the domain, but will need additional refinement after feedback from users. Refinement gets it ready for formalization into a *target ontology,* stage in which an ontology is set for implementation.

To better serve as a means of communication between the developer and the users, the seed ontology has sacrificed formal rigor in favor of easy comprehension. For example, classes and their own instantiations often coexist on the concept maps in a hybrid yet intuitive representation (e.g., "state" and "North Carolina", "Virginia", etc.).

The conceptualization phase is typically followed by the formalization of the concept model followed by the implementation of the ontology. This study proposes an intermediary phase of development where the TBS Ontology model is evaluated to verify its appropriateness and potential usefulness. The evaluation of the TBS Ontology model is addressed in the following chapter and concludes the development process contained in this study. However, before proceeding with the evaluation study, the phase of formalization will be discussed. Although formalization has not been performed in the context of this study, formalization requirements have been taken into consideration in the context of the TBS Ontology construction and guidelines for future development are indicated in the next section.

5.2.4. Formalization

Formalization is concerned with the description of concepts, their attributes, and their relationships in some representation form that can range from natural to logical language. The TBS Ontology is likely to receive an intermediate level of formality between the structured natural language of the semi-informal ontology and the axiomatic level of formality of heavy-weight ontologies that require theorems and proofs of properties (Gomez-Perez et al., 2004). When choosing a representation formalism, the tradeoff between expressiveness and computational advantage, along with issues of scalability, should be considered by the developer in relation to the overall objectives of the system. High degrees of formality facilitate machine processing and enable sophisticated reasoning processes, but also increase the level of complexity of the ontology. The expressive power of a representation language can often conflict with its computational tractability (Brachman & Schmolze, 1985).

A suitable candidate to express the TBS Ontology is Web Ontology Language (OWL), an open standard developed by the W3C that has become the main standard language for the representation of ontologies on the web and is currently supported by major ontology editors (McGuinness & Van Harmelen, 2004).

OWL has a well-founded semantics based on Description Logics, a sub-set of first-order logic for expressing knowledge about concepts and concept hierarchies. Built upon RDF and RDF Schema, OWL offers greater machine readability of web content. In fact, in addition to the basic features that RDF Schema provides in terms of class declaration and hierarchical organization of classes and properties, OWL defines a variety of constructs to represent new concepts and relationships more complex than the traditional subsumption. Specifically, OWL enables logical combination of classes such as intersections, unions, and complements and allows axioms on properties including transitive, symmetric, functional, and inverse. Essentially,

OWL provides more logically defined information about classes and the relationships between them.

OWL allows a choice among three sub-languages, each with increasing complexity: OWL Lite, OWL DL, and OWL Full. Developers choose which OWL dialect to use based on the level of complexity and level of detail required by their semantic model. The intermediate OWL DL provides the formality necessary to constrain the interpretations of concepts and relations in order to perform reasoning tasks. Thus, it appears to be a good candidate for this project because it offers a level of complexity and detail appropriate for the TBS semantic model without adding unnecessary computational complexity. As discussed earlier, the knowledge domain of history is dominated by vagueness and abstraction and may require flexible solutions when it comes to representing the ontology model through logic formalisms. The flexibility OWL provides for describing information structures such as hierarchies, vocabularies, and taxonomies and for modeling a variety of relationships may prove particularly suitable for this task. Indeed, OWL DL is excellent for subsumption and thus for supporting queries that can take advantage of taxonomic knowledge. On the other hand, it does not contain specific primitives for parthood relations. However, reasoning over part-whole relations is a daunting task, as mentioned earlier in relation to spatial relations. Nonetheless, OWL DL provides alternative constructs suitable to capture most of the types of parthood (see Figure 5.3) including transitive and inverse relations (Rector & Welty, 2005).

```
<owl:Class rdf:ID="Country">
<rdfs:subClassOf rdf:resource="#State"/>
<owl:equivalentClass rdf:resource="#Nation"/>
<owl:Restriction>
<owl:onProperty rdf:resource="#part_of"/>
</owl:Restriction>
</owl:Class>
```

Figure 5.3. OWL representation of the relation of parthood between “state” and “country.”

Another interesting feature OWL, and therefore OWL DL, offers is extensibility. Domain knowledge is hardly complete. Interpretation of history is constantly evolving and is likely to require additional meanings. If new concepts need to be included, OWL provides the openness and extensibility required to incorporate additional knowledge (World Wide Web Consortium, 2004). Also, because of its status of open standard, OWL ontologies can be published and shared on the web making its semantics sharable without the limitation of being tied to local applications and repositories.

5.3. Summary

The development methodology of the TBS Ontology discussed in this chapter included the phases of specification, knowledge acquisition, and conceptualization. In addition, guidelines for formalization have been presented. At this stage of development, the TBS Ontology has reached the form of conceptual model. An additional step is introduced to the standard development methodology that consists of the evaluation of the ontology model. This is a sub-phase of the conceptualizing phase wherein the ontology model – or *seed ontology* - is assessed in preparation for later consolidation and conversion that would lead toward a *target ontology*

ready for formalization and implementation. The evaluation study is discussed in the following chapter.

CHAPTER 6

PHASE III: EVALUATION STUDY

This chapter describes the study conducted to evaluate the conceptual model of the TBS Ontology and discusses the major findings. The purpose of the study was to assess the TBS Ontology model from the perspective of end users and examine the appropriateness of the ontology model and its potential usefulness for facilitating access to, and use of, primary sources in the classroom.

6.1. Methodology

Ontology evaluation can be conducted using two major approaches (Noy & Hafner, 1997). The first approach is concerned with the evaluation of the formal quality of the ontology and addresses the formal features, including consistency and completeness, and is performed after the formalization stage. This approach represents the most common type of evaluation that aims at measuring the technical efficiency of the ontology and, ultimately, of the system implementation. The second approach for ontology evaluation is concerned with assessing the utility and usability of the ontology. Gomez-Perez et al. (2004) define such assessment as a practice for "judging the ontology content from the user's point of view" (p. 179). This approach is qualitative in nature and aims at assessing the adequacy of the ontology for its intended tasks and how well it represents the domain of interest. As mentioned earlier, although the evaluation of the formal features of an ontology is a well-established practice, the notion of empirical

usability testing is still almost non-existent within ontological engineering (Gruninger & Lee, 2002). The literature on ontology evaluation from the user's perspective is limited. Staab and Studer (2004) address what they call user-focused evaluation in the form of log file analysis to assess usage patterns of an ontology within an application system. However, the authors recognize that this type of evaluation remains largely unexplored.

The type of evaluation proposed in the present study is user-centered and involves social studies teachers, representing the community of end users most likely to make use of the ontology-driven TBS learning objects. This study is intended to evaluate the conceptual model of the ontology whose design has been informed by the outcomes of the interviews described in Chapter 4. The goal was to receive feedback for refinement and consolidation of the TBS Ontology model before its transition to the formalization phase. In this study, the TBS Ontology is a *seed ontology* within an iterative development process aimed to eventually produce a mature *target ontology* suitable for real world implementation. The rationale for introducing this sub-phase was the assumption that sound conceptual models are a necessary condition for effective implementations of ontology-based systems. The evaluation of ontology models is not common in ontology engineering and the lack of established methods represents an open research issue. Related work can be identified in the field of thesaurus evaluation (Owens & Cochrane, 2004). However, research in this area focuses primarily on lexical aspects of vocabularies, making it only tangentially relevant to the task addressed in this study.

On the other hand, conceptual modeling evaluation has a relevant place in software engineering. In this field, the assessment of the quality of conceptual models in the early stages of software development has long been recognized as essential to determine the general quality of an information system (Lindland, Sindre, & Solvberg, 1994). In this context, the literature recognizes the need for a clear set of methodologies to support the practice of evaluating concept

models (Brewster, Alani, Dasmahapatra, & Wilks, 2004). Moody (2005) offers a review of research in conceptual model quality and highlights theoretical and practical issues that are still unresolved. A major concern is the lack of a common standard for assessing the quality of conceptual models, despite the number of different quality frameworks proposed in the literature. To date, conceptual modeling is still crafted and assessed in a relatively *ad hoc* fashion, which means that it largely relies on subjective views and common sense.

This evaluation study presents a double element of novelty in that it proposes the evaluation of the conceptual model of the TBS Ontology and adopts a user-centered perspective. Two major criteria have been identified to evaluate the TBS Ontology model: design appropriateness and perceived usefulness.

Design appropriateness is concerned with the ability of the ontology model to capture and represent teachers' searching needs. More specifically, the goal was to find evidence that indicates whether concepts and relationships which might be relevant to the end users in their seeking process are adequately represented in the ontology model. The notion of appropriateness can be viewed as context-dependent in that it measures the quality of the ontology model based on actual end user perspectives. In this respect, design appropriateness is intended to assess the quality of the ontology model in terms of content, organization, and terminology. As for the latter, it is important to recognize the distinction between lexical and conceptual level of the ontology. The lexical level provides the vocabulary to denote ontological concepts and relationship and is indeed an important aspect to be considered when the ontology model needs to be communicated between people.

Factors that were considered included:

- Coverage: Is the ontology within the scope of the domain of interest? Are there relevant concepts missed? If not explicitly asserted, could they be inferred?

- Structure: Is the level of granularity adequate? Are there missed relationships?

- Language: Is the terminology appropriate? Do terms reflect the users' language?

Perceived usefulness is concerned with the capability of the ontology to facilitate discovery of, and access to, the learning objects as perceived by the study participants. One way the ontology may prove useful is by helping the teachers formulate their information needs during the search process. This could occur when the ontology suggests query terms, connections between concepts/terms, or potential browsing categories to support the seeking process. Other instances of usefulness may be identified when the ontology prompts unanticipated search possibilities that would help teachers refine or expand their information needs. Perceived usefulness could also provide an indication of the attitude of the participants toward the tool and their intention to use it. Perceived usefulness is one of the two measures (the other one being *ease of use*) recognized by Davis (1989) as essential for predicting user acceptance of new technologies. Factors that measure perceived usefulness as identified in Davis study were taken into consideration in the development of the study tasks. In particular, they inspired the last three questions of the Task 3 debriefing questionnaire (see Appendix X).

6.2. Overview of the Study

The TBS Ontology model described in Chapter 5 was evaluated by conducting a task-based user study. The study was conducted and observed by the investigator and took place in the participants' workplaces and in the usability lab of Davis Library. Each session was preceded by the participant reading and signing an informed consent form and completing the same demographic questionnaire as used in Phase I (see Appendix II). The session consisted of three tasks. The researcher followed the script shown in Appendix XI in giving instructions

for each task. The first two tasks required the participants to search for digital primary sources using Google and the TBS collection of learning objects. The searches were screen recorded. The third task involved the examination and annotation of a series of five paper-based concept maps during which participants were encouraged to share their thoughts out loud. Each task concluded with a debriefing interview during which participants were asked to comment on their experience. Protocols and session debriefings were audio-taped. The test was piloted with a local social studies teacher to verify the time required to complete the test, and that the tasks were well-structured, the questions were clear, and the concept maps made sense. Minor changes were made after the pilot test in order to maximize the utility of the study and facilitate the flow from task to task.

6.3. Study Participants

A total of fourteen social studies teachers from middle schools and high schools in Central North Carolina participated in the study. As in most qualitative studies, sampling was purposive (Hamilton & Bowers, 2006). The sample was chosen based on appropriateness to the research purpose (6-12th grade social studies teachers, who represent a primary community of users of the TBS Ontology), adequacy (the size of the sample was likely to provide data sufficiently rich and detailed for the goal of the study), and available resources. To be eligible to participate in the study, teachers needed to have experience with teaching social studies and to have used digital primary source materials for classroom instruction. Teacher participants were recruited in several ways, including e-mails and direct solicitation. A snowball sampling plan was pivotal in increasing the number of participants.

Interviews and tests took place over a three-week period with fourteen individual sessions lasting between sixty and ninety minutes each. The study participants ranged in age from twenty-

five or younger to fifty or older. The majority of participants were female (64%). Sixty-four percent of the participants held a master's degree in Education. Their teaching experience spanned from one to thirty years with a mean of six years.

In addition to demographic information, the study participants answered several questions regarding their experience with computers and the Internet, as well as the characteristics of their schools. Their self-rated computer/Internet experience ranged from beginner (7%) to intermediate (57%) and advanced (36%). They all used primary source materials for instruction and identified the web as the main source for searching primary sources (textbooks and libraries came second before personal collections). More than half had used North Carolina digital collections and DocSouth in particular.

Suburban and rural schools were equally represented (43% each), while only 14% worked in urban schools. The student bodies were predominantly white in 57% of the teachers' schools. About half of the schools had students at a middle socioeconomic status. All had access to Internet in their classrooms with at least one computer available in the classroom. According to participants, about 75% of their students had Internet access at home.

6.4. Procedures

6.4.1. Task 1

Task 1 consisted of searching digital primary source materials with the goal of simulating a lesson preparation. The purpose of the task was to gather user queries that could be used to assess the appropriateness of the ontology model and observe teachers' normal approach to searching for primary source materials. The searches were performed on Google, the most common search service used by the teachers as discovered in Phase I interviews and in the literature. Each participant was given two questions on paper that represented realistic scenarios

on the subject of the Great Depression. The task questions were inspired by the teaching activities described in the interviews and adapted from the North Carolina Standard Course of Study – Social Studies – United States History, adopted in North Carolina schools: [71]

> **Q1.** Assess the impact of the Great Depression on the day-to-day life of a low-income family in Virginia in the 1930s.
>
> **Q2**. Analyze the effects of the New Deal policies on the Depression Era life of women in North Carolina.

[0]

Participants continued to perform their searches until they considered their findings satisfactory for the purpose of the task. The searches were captured on screen. Task 1 ended with a debriefing during which the participants were encouraged to share their thoughts about the searching experience in order to determine whether they: (a) found the searches easy; (b) had any problems thinking of suitable query terms; (c) felt they had all the information needed to perform the searches; and (d) took a particular approach to the searches and, if so, why.

6.4.2. Task 2

For this task, the TBS collection of learning objects was introduced and the participants were asked to search the collection with the goal of finding learning materials useful for instruction. First, the researcher gave participants a brief overview of the TBS collection, following the script in Appendix XI. Participants were then given a few minutes to explore the website and to ask any questions they had. Then, the following two questions were presented on paper. The questions reflect the scenarios derived from the Phase I interviews and based on the

[71] The questions for Task 1 were adapted from Competency Goal 6, Objective 6.01 of the North Carolina Standard Course of Study's Eighth Grade Social Studies Curriculum: "Identify the causes and effects of the Great Depression and analyze the impact of New Deal policies on Depression Era life in North Carolina." (http://www.ncpublicschools.org/curriculum/socialstudies/scos/2003-04/050eighthgrade).

North Carolina Standard Course of Study – Social Studies – United States History, adopted in North Carolina schools: [72]

> **Q3.** Identify the role of tobacco in the economic development of North Carolina in the 1930s.
>
> **Q4.** Describe the differing impact of the Depression on various minority groups.

Participants were asked to perform searches with the goal of finding learning materials useful for instruction based on the given scenarios. Half of the participants saw Q3 first; the other half saw Q4 first in order to reduce potential learning effects. Participants performed the search twice for each task question. The first time the search was performed using the search interface of the TBS collection[73] (see Appendix XVII). Participants were asked to continue searching until they were satisfied with the results without exceeding a ten-minute time limit. The second time a faceted interface on paper was presented to the participants (see Appendix XII). This paper-based search interface displayed the main categories from the TBS Ontology in the form of expanded facets. The facets included almost all the concepts from the ontology model developed in the study. Due to space limitations the category "education" was excluded because it seemed unlikely to be useful in the context of the task questions. A brief explanation informed participants that the paper-based interface intended to simulate a faceted search or drop-down menus they might have encountered and used before (see Appendix XI). Participants were asked to consult the interface on paper and then to reformulate the queries from task 2 they

[72] The questions for Task 2 were adapted from Competency Goal 5, Objective 5.01 of the North Carolina Standard Course of Study's Eighth Grade Social Studies Curriculum: "Identify the role played by the agriculture, textile, tobacco, and furniture industries in North Carolina and analyze their importance in the economic development of the state (http://www.ncpublicschools.org/curriculum/socialstudies/scos/2003-04/050eighthgrade); and Competency Goal 9, Objectives 9.04 of the North Carolina Standard Course of Study's Eleventh Grade Social Studies Curriculum: Describe challenges to traditional practices in religion, race, and gender" (http://www.ncpublicschools.org/curriculum/socialstudies/scos/2003-04/067eleventhgrade).

[73] http://dc.lib.unc.edu/cdm4/search.php.

had performed earlier. Search terms and phrases from the entire session were recorded through screen recording software.

Upon completion of the task, a debriefing interview was conducted to understand whether and how the availability of ontology categories through the paper-based facets had impacted the search process (see Appendix XIII). The interviews were audio taped.

6.4.3. Task 3

For Task 3 the participants were asked to manually navigate and annotate paper-based concept maps representing the ontology model on the basis of two scenarios. The purpose of the task was to (a) obtain data to assess the quality of the ontology model through the protocol analysis and concept maps' annotation and (b) gain feedback on the perceived usefulness of the ontology through the session debriefing. First, the participants were introduced to the ontology model in the form of five concept maps corresponding to the upper-level categories of space, time, people, and domain-specific concepts (see Appendices V-IX). The maps were numbered and displayed simultaneously and in the same order for each participant. The researcher explained the task with the following scenario: "Imagine that you need to prepare a class on the Great Depression and you would like to find some primary sources that illustrate the following aspect to your students: 'What was life like for children of your age in different areas of North Carolina during the Great Depression?' " (see Appendix XI). This question worked as a model for each participant and the researcher described how a search could be guided or constructed using the concept maps by drawing paths and circling concepts. Next, the participants were given a clean set of diagrams and were presented with Questions 1 and 4 from the previous two tasks, one at a time. These questions were chosen because they offered a range of navigation options that would encourage the participants to examine various sections of the ontology. To complete

the task, participants were required to perform self-directed walk-throughs of the concept maps. Specifically, participants were asked to manually navigate the concept maps and show their exploration and seeking process by drawing their search paths with colored pencils and circling target concepts they would select for their queries. They were also invited to annotate the diagrams and write down any questions, concerns, or suggestions they might have.

During the task, participants were encouraged to share their thoughts as they navigated the maps, following the think-aloud protocol. This method required participants to express their thoughts as they performed the task (Ericsson & Simon, 1993). The researcher gave only general instructions (e.g., "Try to think-aloud and verbalize everything that passes through your head") to avoid influencing the participant. The researcher interacted occasionally with probes to remind participants of thinking-aloud when they seemed to forget. Upon completion of the task, participants were debriefed on the experience (see Appendix X). The entire session was audio taped.

6.5. Results

6.5.1. Task 1

Task 1 yielded the queries teachers constructed to find primary source materials for the topics specified in Questions 1 and 2. Participants were instructed to continue searching until they considered their findings satisfactory; each participant spent between five and ten minutes on each question. Search keywords and phrases were collected for each of the two task questions and mapped onto the ontology model. Terms were also compared to the content words in the original questions. Each search term was categorized by the degree of match with terms in the seed ontology and original question using the categories defined in Table 6.1. In this context, the

notion of variant was interpreted in a broad sense, both as lexical (singular/plural – minority/minorities) and conceptual (synonym – impact/effect).

Match Category	**Definition**	**Example** User term/ontology/question
Same as ontology only	historical match between a user's search term and an ontology term	Example: Wage/wage
Same as question only	Exact match between a user's search term and a question term	Example: Impact/impact
Same as both ontology and question	Exact match between a user's search term and both an ontology term and a question term	Example: Tobacco/tobacco/tobacco
Same as ontology Variant from question	Exact match between a user's search term and an ontology term, but a variant from a question term	Example: Income/income/low-income
Same as question Variant from ontology	Exact match between a user's search term and a question term, but a variant from an ontology term	Example: Women/women/woman
Variant from ontology only	User's search term is a variant from an ontology term	Example: African Americans/African Americans
Variant from question only	User's search term is a variant from an ontology term	Example: 1930/1930s
Variant from both ontology and question	User's search term is a variant from both an ontology term and a question term	Example: Families/Family/family
Candidate for ontology inclusion	User's search term that express a concept not present in the ontology but worth consideration	Example: Rural
Out of scope	User's search term not pertaining to the subject matter, for example specifying genre.	Example: Diary

Table 6.1. Categories of matching.

The mapping provides clues as to whether the users' query terms were formulated independently or derived from the text of the questions and whether the ontology included the users' query terms. The data analysis was intended to identify potential concepts/terms to be considered in the revision of the ontology. Table 6.2 presents a complete list of search terms and phrases used for both questions, along with the number of times they were used. Each search term was counted cumulatively for each question.

	Question 1		Question 2	
Categories of matching	**N.**	**Terms/phrases (number of occurrences)**	**N.**	**Terms/phrases (number of occurrences)**
Same as ontology only	0		1	Legislation (1)
Same as question only	3	1930s (13) Day-to-day life(1) Impact (1)	3	Effects (2) Life (1) Policies (5)
Same as both ontology and question	3	Great Depression (36) Virginia (41) Family (8)	2	New Deal (2) North Carolina (27)
Same as ontology Variant from question	1	Income (5)	1	Great Depression (2)
Same as question Variant from ontology	1	Low-income (6)	2	Depression Era (5) Women (20)
Variant from ontology only	0		0	
Variant from question only	2	Life (2) Family life (5)	2	Effect (1) Impact (2)
Variant from ontology Variant from question	2	Depression (1) Families (7)	1	Females (1)
Candidate for ontology inclusion	1	Rural (1)	0	
Out of scope	9	Diary (1) Firsthand account (1) Photography (1) Photograph (2) Primary resources (2) Primary sources (6) Richmond Newspaper (1) Sources (1) Waltons (1)	2	Personal setters (1) Primary sources (2)
Total	22		14	

Table 6.2. Search terms for Question 1 and Question 2.

Contrary to what was expected, the analysis of the search terms did not provide much useful data to assess the ontology model itself. For example, only one concept was identified as a possible candidate for inclusion in the ontology. However, the results offered an insight on

participants' search strategies, revealing that the search terms were heavily dependent on the words and phrases in the question. The first question contained 7 content words or phrases. Out of the 13 user terms that were considered within the scope of the topic, 12 were from the question either as an exact match or as a variant. The second question contained 7 content words or phrases. Out of the 12 user terms that were considered within the scope of the topic, 11 user terms were derived from the question either as an exact match or as a variant. In other words, only one user term for each question was not from the original text (*rural* and *legislation*). The limited range of search strategies revealed by the results of this task contrasts with the variety of ways teachers had described how they would search for primary sources during the interviews discussed in Chapter 4.

Qualitative data were also collected during the debriefing that followed the completion of each task question, where participants were asked to provide feedback about the searches they had performed. All but three teacher participants found the searches to be somehow problematic. Several participants found the searches related to the first question difficult while they found it easier to search for the second question. The main source of frustration was the difficulty in finding resources at the right level of specificity. For example, one participant commented, "You find a lot about the Great Depression, but when you minimize it to a smaller search I had a hard time finding an example of a Virginia family." Another participant observed, "I could find stuff on the Great Depression in Virginia, but not for low-income families. I couldn't get it narrow enough." Other participants found very specific sources, but for a state other than the one indicated in the task question. Three participants found searching for the second question particularly frustrating when trying to locate sources related to women. One participant commented, "It wasn't the easiest. The thing with the second one with the life of the women, particularly in North Carolina, I had a hard time finding a source. There is a lot of information

out there on the Great Depression, but when you try to make the search smaller…at that point when I couldn't find the information I was looking for I would maybe go to the library."

6.5.2. Task 2

Task 2 yielded teachers' queries used to find relevant materials in the TBS collection, first using the existing interface alone, then after consulting the seed ontology facets and terms. The objective of Task 2 was to gather evidence to assess the perceived usefulness of the ontology and to collect additional data to be used to evaluate the design appropriateness of the ontology model. The query terms before and after the use of the paper-based facets from both search sessions were collected and analyzed. As before, users' search terms were compared to the seed ontology and the original questions. A summary of results from each session is shown in Table 6.3 and Table 6.4.

Question 3: Identify the role of tobacco in the economic development of North Carolina in the 1930s				
		Before Facets		**After Facets**
Categories of matching	**N.**	**Terms/phrases (number of occurrences)**	**N.**	**Terms/phrases (number of occurrences)**
Same as ontology only	2	Wage (1) Labor (1)	14	AFDC (1) Agriculture (5) Cottage industry (1) Crop (1) Family (1) Great Depression (11) New Deal (5) Piedmont (1) Program (2) Southwest (1) Stringing (1) Tobacco Bag Stringing (4) TVA (1) Wage (1)
Same as question only	3	1930s (10) Economic development (8) Role (7)	3	1930s (9) Economic development (1) Role (1)
Same as both ontology and question	2	North Carolina (9) Tobacco (9)	2	North Carolina (13) Tobacco (8)
Same as ontology Variant from question	1	Economy (4)	2	Economy (6) Tobacco economy (1)
Same as question Variant from ontology	0		0	
Variant from ontology only			3	Jobs (1) Orange county (1) Welfare (1)
Variant from question only	6	Economic impact (2) Economic issues (1) Economic role (1) Economic tobacco (1) 1930 (3) Development (2)	0	
Variant from ontology Variant from question	1	Tobacco industry (2)	0	
Candidate for ontology inclusion	5	Eastern North Carolina (1) Tobacco cultivation (1) Tobacco product (1) Money (1) Poverty (1)	0	
Out of scope	0		0	
Total	20		24	

Table 6.3. Search terms for Question 3.

Question 4: Describe the differing impact of the Depression on various minority groups				
	Before Facets		**After Facets**	
Categories of matching	**N.**	**Terms/phrases (number of occurrences)**	**N.**	**Terms/phrases (number of occurrences)**
Same as ontology only	1	African American (3)	15	African American (1) American Indian (1) Asian (5) Farmer (1) Immigrant (1) Labor (2) Labor movement (1) Lower class (2) Middle class (1) North Carolina (2) Sharecropper (2) Social status (1) United States (1) Upper class (1) Tobacco Bag Stringing (1)
Same as question only	2	Impact (2) Minority groups (10)	1	Impact (2)
Same as both ontology and question	0		0	
Same as ontology Variant from question	0		1	Great Depression (9)
Same as question Variant from ontology	1	Depression (7)	0	
Variant from ontology only	8	African Americans (6) Blacks (1) Immigrants (1) Migrants (1) Migrant (1) Native Americans (1) Tobacco Bag Stringing (2) Women (4)	5	African Americans (1) American Indians (2) Asians (1) Wall Street (1) Women (1)
Variant from question only	3	Effect (2) Minority (6) Minorities (7)	2	Effects (1) Minorities (3)
Variant from ontology Variant from question	2	Depression era (2) Great depression (12)	0	
Candidate for ontology inclusion	0		0	
Out of scope	0		0	
Total	17		24	

Table 6.4. Search terms for Question 4.

The researcher looked at changes in the general approach to the searches and, more specifically, at possible changes in the formulation of the queries and at whether these changes might have been influenced by the display of the ontology categories through the paper-based facets (i.e., whether new query terms were picked from the facets).

The third question contained 5 content words or phrases. Users derived 13 search terms from the question between exact matches and variants before the use of the facets. The post-facet search revealed a slight decrease in the use of question terms (7 in total), but a remarkable use of terms derived from the facets (18 exact matches and 3 variants).

This trend was confirmed by the results from the fourth question. The fourth question contained 4 content words or phrases. While 8 user terms were derived from the question text (3 exact matches and 5 variants), in the post-facet search only 1 exact match and 3 variant terms were derived from the question, but 16 exact matches and 5 variants were derived from the facets.

There was some learning effect, in that teachers seemed to carry over what they had seen in the facets for their first question to their second question, regardless of the order in which they saw the questions. For example, for teachers who saw question 4 first, 2 exact matches from the facets were used in the pre-facet search for their second question, question 3. Similarly, teachers who saw question 3 first used 1 exact match from the facets and 8 variants from the facets in the pre-facet search for question 4.

Data from the session's debriefing were analyzed with the intent of understanding whether and how the availability of ontology categories through the paper-based interface had an influence on participant's approach to searching and, if so, what kind of influence it had.

All the participants found the facets useful. Several participants pointed out that the facets helped them with query formulation. Eight participants observed that the facets suggested terms

they would not have thought about on their own. One participant noted that "it was easier to search the second time with this list - that was helpful to advance my search." Another commented that "there are definitely some keywords on here that would help me in my searching that you don't often think about" and indicated *social status* as an example of something that had not occurred to him without the facets. One found the *race* and the *historical period* categories and sub-categories very helpful. Two participants suggested three concepts/terms that should be included: *education,*[74] *development*, and *culture.*

Several participants valued the fact that the facets offered them an overview of what the collection would offer. One commented that "it helps you to understand something about the collection" and another reported that the menu "gives you an insight to what is there." A pair stressed the fact that "this tells you what is available" and "it would explain what is there and what is not."

One participant explained that the facets helped him make more focused choices: "I really liked the list because as you are looking for something, you are brainstorming with all these thoughts in your head and this jogs your memory." Another participant commented that she "can tailor [her] search based on what's here." One participant commented that it helped him make informed decisions useful for his class planning: "I may not have decided that I wanted to talk abut the TVA specifically tomorrow, but this tells me I can look for something on the TVA. On the other hand, this tells me – right off the bat – that I am in the wrong place if I am looking for the CCC.[75] So by default I know exactly what is here."

Four participants highlighted the usefulness of the facets for narrowing down their search options and thus avoid having to browse the whole collection. This was a way for them to save

[74] "Education" was actually included in the ontology, but not displayed on the menus.

[75] Although included in the ontology, "CCC" was not among the terms displayed on the menus under "program." Because of space constraints only a few types of programs were displayed.

time. One participant pointed out the value of the facets for large collections of digital primary sources: “the more elaborate the collection the more this would be useful, like DocSouth.” Two other participants noted that the facets helped them with the vocabulary. For example, one pointed out that she was not thinking of using African American as a search term because she tried to think “of what they would have labeled it back then, so I got no hits for like ‘blacks’ or ‘Negroes’.” Another commented that “I would type in Native Americans and not American Indians, which might have affected what I pulled.” He stressed the fact that “it [is] easier to know what the keywords are that are plugged into the system than having to know on my own what the keywords would be.”

When asked if the facets had prompted suggestions for teaching, several participants gave examples of ideas they got while examining the facets. One stated, “Looking at the terms I have lots of ideas running through my head on lessons I could relate. When it is this easy to find material, it gives you more time to be creative, because I don’t have to spend all of my time searching for stuff.” One participant laid out a teaching activity that the facets had prompted to her: “I would set up a cooperative learning with this. Since it is very detailed, I would arrange my students into small groups and give them families and have them represent the family. I would give them some questions to think through. How might life have been, how was school, or the house they lived in…” Another observed that, more than ideas about activities, “it would give me ideas about other topics that I could tie in.” For example, she mentioned *child labor* in relation to the tobacco industry.

Teachers' reactions to being able to use an implemented version of the paper-based faceted interface were in general very positive: “I am wishing I could click on it and make lessons. There are a lot of interesting terms here” or “I would use it frequently because it would tie to what I teach.” Also, when asked to comment on the appropriateness of the terminology, the

vast majority found the use of the words similar with what they would use: “These terms are excellent - these are the perfect terms and if you can't find something using these, you're in trouble.”

6.5.3. Task 3

Task 3 data was used to (a) obtain data to assess the quality of the ontology model through the protocol analysis and concept maps’ annotation and (b) gain feedback on the perceived usefulness of the ontology through the session debriefing.

With different levels of detail and sophistication, participants annotated the concept maps circling the target concepts and drawing connections between these concepts according to their flow of thinking in relation to the scenarios proposed by the two questions. Samples of teachers' annotated maps are shown in Appendixes XIV-XV.

The analysis of the drawings and annotations revealed that participants’ pathways varied as to starting point and direction, but they focused on similar clusters of concepts. For both questions, the majority of participants started from targeting the time period and then proceeded towards the geospatial concepts reaching their preferred level of specificity. Four participants adopted a reverse strategy starting from the geospatial area. Three participants chose the category of person as a starting point, but then performed the actual drawing starting from either the time or the geospatial concepts. The category of person was either the second or the third step for the large majority of participants. Within this category, the most targeted concepts were child and adolescent, family and its various members, and racial groups depending on the task questions. The categories of economy and labor were the ones more heavily marked, especially concepts and connections that would serve to represent the notion of “low-income” as addressed by

Question 1 and “differing impact of the Depression” as in Question 4. A wide range of concepts for expressing the notion of “day-to day life” from Question 1 was chosen (see Figure 6.1).

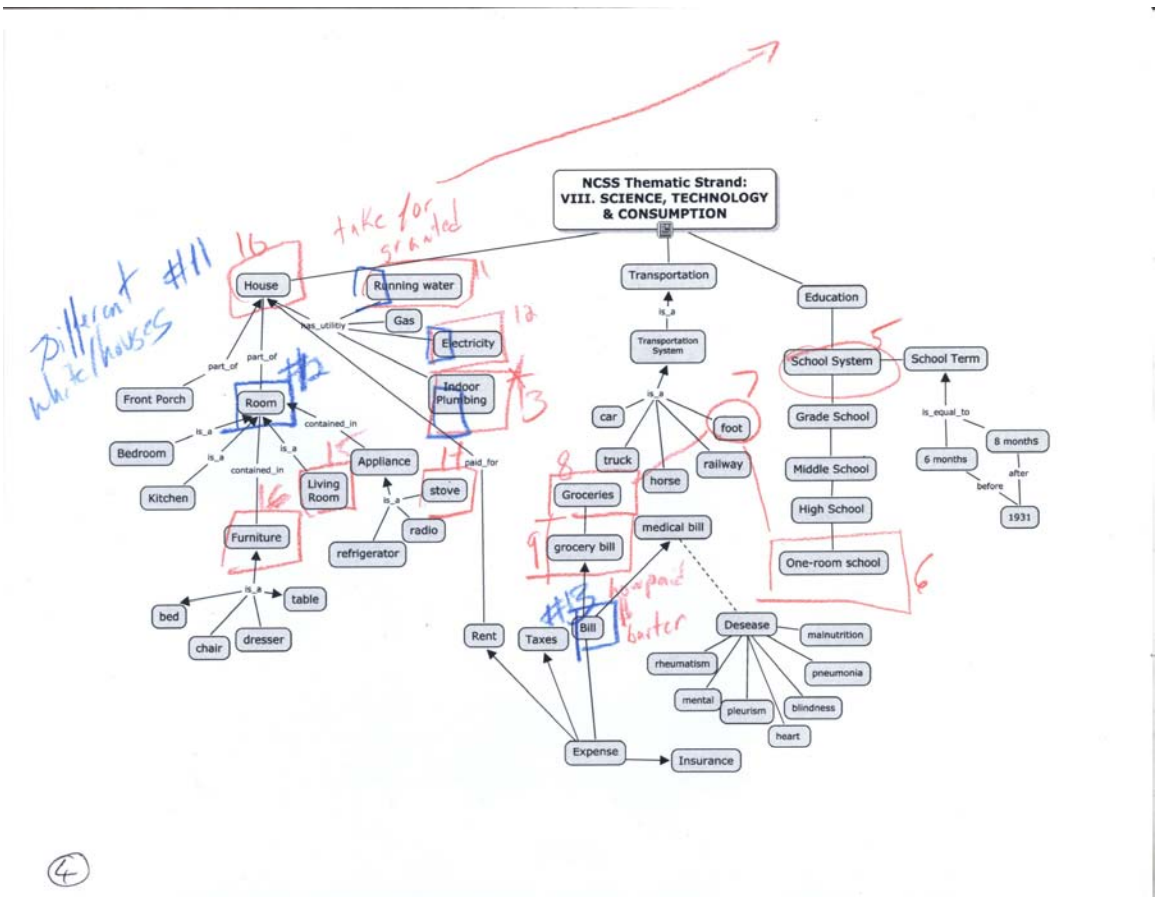


Figure 6.1. Teacher's annotated concept map for "day-to-day" for Question 1.

A comparison of all the maps utilized in the study revealed that every single concept from the category of house, transportation, and education had served as a target concept and was circled in at least one session. Six participants annotated the maps with suggestions for additional concepts. A cumulative list of participants’ concepts/terms directly suggested or derived from queries during the three tasks is presented in Appendix XVI.

The protocol analysis that accompanied the navigation and annotation of the concept maps was particularly rich and revealing. Due to the familiarity most of the participants had with the use of concept maps as an educational tool, the flow of thinking and the concurrent verbalization were, in general, smooth. Participants seemed to be comfortable with this means of communication and even diverged at times from the strict protocol to add spontaneous comments that were insightful for the researcher. During the session debriefings, the researcher used the guided recall protocol to elicit explanations on specific issues of particular interest for the study. Additionally, the debriefing interviews included questions intended to solicit feedback on the clarity of the concept maps, their completeness, and their correctness from their perspectives as teachers. Participants were asked to provide suggestions for improvements and to comment on whether they found the maps useful for their searching tasks.

The results of the analysis of the protocol and debriefing transcriptions are combined in the following section. A series of key themes were identified that could contribute to the assessment of the ontology model. These themes include: temporal and geospatial dimension, coverage and modeling issues, clarity, and usefulness.

6.5.3.1. Temporal and Geospatial dimension

As mentioned earlier, the category of time was chosen as a starting point by several study participants. The periodization was considered appropriate and was recognized by participants as the way they typically identify time periods in their teaching and learning activities (see Appendix XV). For further development of the ontology model, one participant suggested breaking down the periods before the Great Depression according to the teaching standards and incorporating categories of events, including the Roaring Twenties, the West, and Imperialism as they reflect the periodization adopted in current social studies courses of study.

Annotations and comments on the concept map representing the geospatial dimension indicated that the level of specificity was overall in line with participants' expectations and expressed needs. Several participants commented positively on the presence of "county" that was chosen as a target concept by eight participants. One observed that "this, of course, tells me that I can type in for county, so that is good because when we did the Great Depression we looked at pictures and we wanted to find stuff of the local area." Confirming what had emerged from the Phase I interviews, "county" was definitely the lowest level of specificity teacher participants considered useful in the context of their searches. For one participant this level of granularity was even too specific: "I wouldn't necessarily pick a county unless I had one in perspective." For a pair of participants the optimal lowest level would be "state": "I would stay broad with Virginia, we don't have time to go into much detail" and "I'd use North Carolina and Virginia to get different aspects. That's plenty."

Nobody targeted the concept of city or any of its instances on the maps. One participant commented, "I'd never look at the city – for instance, this area in particular, Chapel Hill, is such a transient place to live that even if I mentioned all these places, no one in my class would know where they are – so it is not meaningful for them. I would never look at breaking it down below counties – because they just wouldn't care." In one instance the concept of city was mentioned, but only in the specific context of a comparison between city life and rural life. The notion of urban and rural is not represented in the ontology model and there is no way to infer something like "Appalachian Mountains are rural." Rural was also one of the terms identified from Task 1 as a candidate to be included in the ontology. This reinforces the need to consider including *rural* along with *urban* when revising the ontology.

One participant was puzzled when looking for Eastern Carolina: "I look for everything east that I know grows a lot of tobacco, like counties east of Raleigh – Eastern North Carolina,

going down east or the sand hills of North Carolina. That's how it is – but it didn't." Another participant tried to identify "Eastern North Carolina because it was the poorest." This geospatial specification was not represented in the TBS Ontology model and participant's comments indicated that it should be considered in future refinements. Regional areas that include the Mountains, the Piedmont, and the Coastal Plain defined in the TBS Ontology as sub-regions of North Carolina appeared to be useful for addressing comparisons ("there are differences between coastal and the mountains – that's broad enough a category for showing those differences").

Interestingly, one participant brought up the notion of neighboring state: "I want to look at what was back then in our neighboring state to the north" (see Figure 6.2). Indeed, the concept map would lead to the "neighboring state" through the relation of "adjacency." The participant's comment helped to validate the usefulness of this relation.

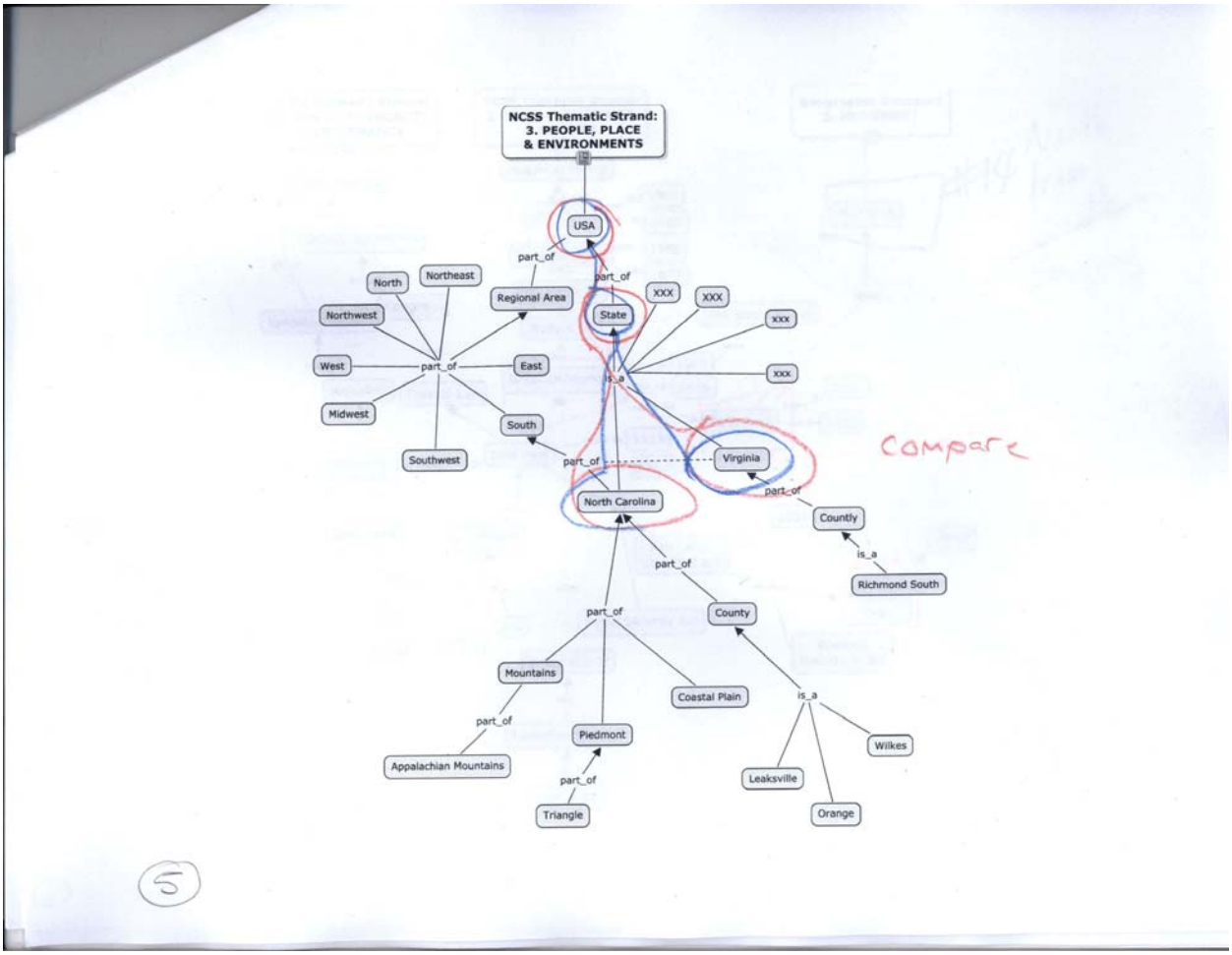


Figure 6.2. Teacher's annotated concept map for comparison between North Carolina and "neighboring state" Virginia for Question 1.

6.5.3.2. Coverage and Modeling Issues

All participants commented in positive terms on the domain coverage offered by the concept maps ("the coverage is excellent"; "all you need is there"). As for further expansion of the ontology, one participant suggested to closely consider the course of study because it is what teachers are going to look to. He explained that in the context of the Great Depression he would look for things like Social Security and he would also "look for challenges that the Supreme

Court had to it." "If that is a consideration," he continued, "then you would have to add the third branch – the judicial branch because I use it."

From the analysis of maps' annotations a few concepts were added by participants that would expand the domain of the ontology in two main directions. One area where new concepts were suggested is the one representing "the day-to-day life of a low-income family" from question 1. Three participants manually added concepts they considered useful for the scenario proposed by the task. Most of these concepts suggest further specifications of, for example, the category of "education" and they represent semantic gaps to be considered in future revisions of the ontology. In one instance, concepts were added that identified very specifically some of the effects of the Great Depression on people (e.g., loss of income, break up of families, or suicide) (see Appendix XIV). These suggestions seemed to express the need for a "cause-effect" type of relationship that the TBS Ontology had not included and pointed out an interesting modeling issue. Knowledge of cause and effect provides the basis for historical interpretation, and inquiry-based learning is indeed based on the concept of causation. For this very reason, representing the notion of causation in a history domain would incur the risk of producing connections that were simplistic, mechanical, and most likely subjective and biased. Another participant had an insightful comment during a guided recall question while focusing on his exploration of the concept maps on the Wall Street crash as one of the causes of the Great Depression: "I think that's the teacher's job. You can't do everything for the teacher. The computer can't. You know, we have to – so we, we're going to have to fill that part in."

Another interesting modeling issue with both conceptual and terminological implications is related to the notion of minority groups addressed in task question 4. Intentionally, the relation was expressed ambiguously ("person" `has_race/ethnicity`) and only four groups were represented (African American, American Indian, Asian, and White). This cluster of concepts

received a lot of attention and was heavily marked mostly because it was the focus of one of the task questions and it is a popular teaching topic. Several participants commented on the usefulness of finding the different groups laid out (e.g., “I have all these different minority groups under race and click on African American, Asian, American Indian, and there is a section on social status to see if there is a cross-reference there. This makes it easy”). A number of additional concepts were suggested and various types of connections were pictured (e.g., “I would put Latino Americans with the migrant labor movements”; “I would want a link to income and how it related to these minorities”) (see Figure 6.3).

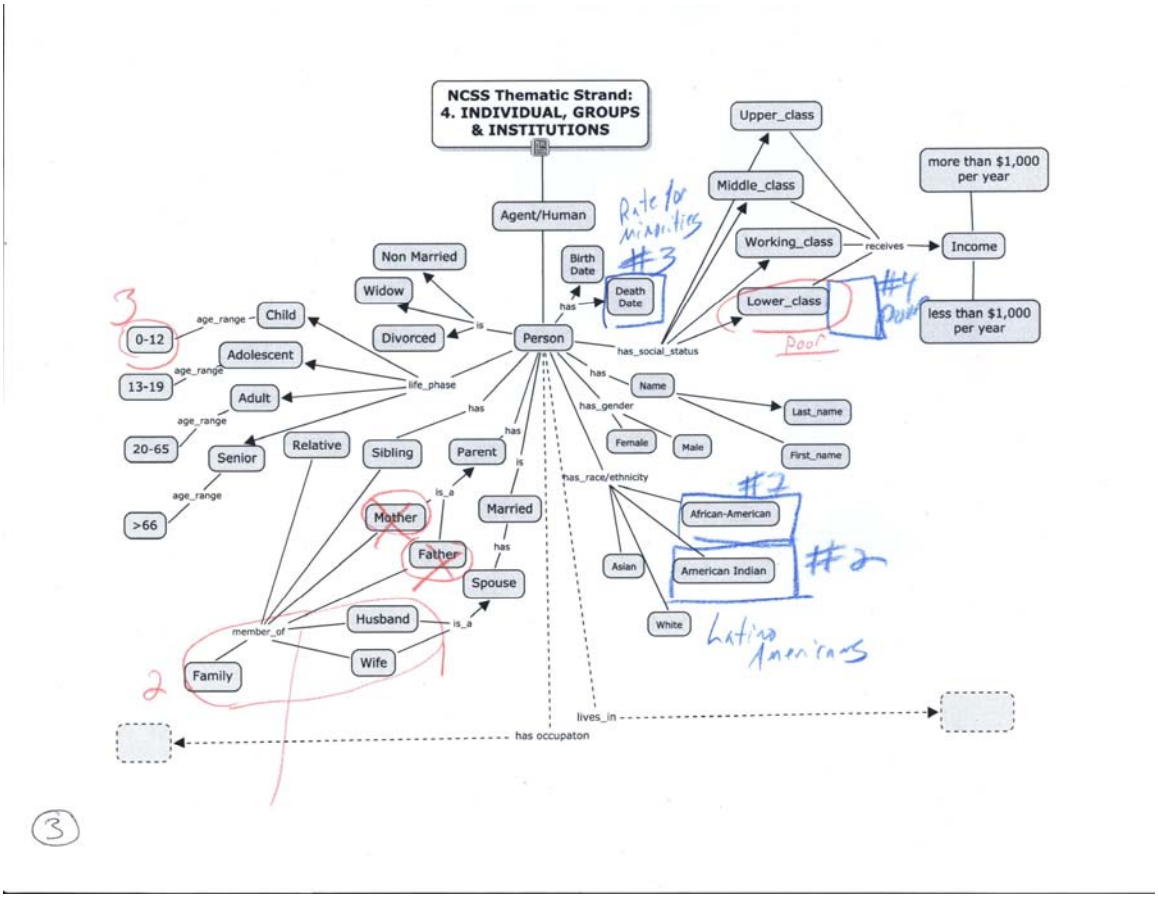


Figure 6.3. Teacher's annotated concept map for "minority groups" for Question 4.

One participant recognized the ambiguity that the concept "minority" may carry when he added "Hispanic." He was puzzled if he should consider it a race or ethnicity and commented: "I think there are lots of anthropologists that would argue there is no race, but ethnicity – I think you need both – leave it like that way." Another took a different approach and related the concept of minority not to racial groups but to women in the workforce.

One participant raised an interesting point on the implications of using the concept "minority." She prefaced that she was very conscious about the terms she uses and "that's why, if I think – well, I'm searching for the impact on different demographic groups in America, because their experience is different, because of how they're perceived in American society, 'minority' is kind of a safe term when we're talking about American history." She argued, "the curriculum is structured with separating groups of people. How did World War II affect African Americans? How did World War II affect women? We don't really think of it as: 'How did World War II affect America?' " Although as a teacher she was frustrated with this type of separation, she recognized that "since that's the model we're forced to work from as teachers, I think it would be useful to have a specific connection that pools the experience of minority groups, because that's something that teachers are going to be searching for." One participant suggested to "sort of get beyond that problem by linking race, ethnicity and minority groups together in a search... But then you still have the dilemma with white Americans, that's a race."

6.5.3.3. Clarity

The vast majority of the participants found the concept maps clear. Because of their familiarity with concept maps, as mentioned earlier, participants were able to gain a sense of the content rather quickly. One commented that "it takes a second, but once I understood what I was looking at, it was a good breakdown." Another stated that "even if it looks cluttered you need

everything that is included to make the connections." Only one complained that she "was a little confused with the lines – I did not know where to start." This comment referred specifically to the issue of transitioning from one map to another and it seemed to have to do more with the display of each page on the table than with the content of the maps. In general, participants commented positively on the organization of the maps ("I think it's laid out beautifully"). Overall, they liked the terminology used ("You are on target with the words").

6.5.3.4. Usefulness for Teaching

The think-aloud protocol that accompanied the navigation and annotation of the maps seemed to suggest a good correspondence between the model of the ontology and the ways teachers conceive and use the domain knowledge represented in the model. In many instances, the choice of concepts and the linking among them was in line with what the design of the ontology intended to support. For instance, the ability to target children or adolescents and to identify relationships within the concept of family was perceived positively as a way "to connect the topic to students from a personal point of view" or to "stress the deep connections in southern families at that time." The capability to support comparisons was highlighted several times: "You can do so much. You can compare a person with a higher socio-economic class to a lower. You can tweak your lesson to have students understand how they differ." One participant recognized and appreciated the opportunities the concept maps provided to interrelate concepts in ways that were useful for his teaching: "I would use African Americans, American Indians, and Asians and contrast how each one was affected. I would break it down into males and females – whether the Great Depression had more effects on the females or males – and then talk about the different areas of the United States; you could talk about how the minority groups in the South were affected differently than the minority groups in the North."

Two participants commented on the potential usefulness of the ontology as an educational tool: “It gives you a lot of ideas about where you could go. You could create almost two weeks worth of lessons off these maps” and “This is something that if this was there, teachers could go to the website and then put it in their folder and add to it.”

Also interesting was the way the maps were viewed by two participants. While exploring and marking concepts and connections, one participant observed that this “would help to tell a story” and constructed an articulate representation of the day-to-day life of children by drawing pathways between the ontology concepts.

Another participant reached similar conclusions and commented that “it makes it easier to fit them into a facet of the daily life so, you know, you can kind of tell the story: ’This is what, you know, Johnny and Susie, a brother and sister, did from the time they got up in the morning’ from what they saw, to what they did throughout their day.’”

The role of ontologies for supporting construction of narratives is an aspect that is still little explored in the literature (Mulholland, Zdrahal, & Collins, 2002), but the potential usefulness of the TBS Ontology to construct stories is an interesting approach that should be explored in the future. Indeed, history education literature has recognized the creation of explanatory narratives as one of the main processes involved in thinking and learning about history (Wineburg, 1994).

6.6. Conclusion

The findings from this Phase III Evaluation study provided a rich set of data to be employed for the evaluation of the appropriateness and potential usefulness of the TBS Ontology. The data also revealed aspects of participants’ search strategies that may have implications on the design of the ontology. Moreover, a set of suggested terms and concepts was

collected that will be considered for future expansion and refinement of the seed ontology. The results of Phase III will be discussed in the context of the overall study in the next chapter.

CHAPTER 7

DISCUSSION

This chapter discusses the major findings of the study, addressing the development of the TBS Ontology, the methods adopted in developing the ontology, the evaluation of the ontology, and the results of the evaluation. The entire study consisted of three sequential phases that included an initial series of interviews to gain an understanding of the user requirements to inform the design of the ontology, followed by the development of the TBS Ontology model or seed ontology, and finally the evaluation of the seed ontology. The study was intended to answer two specific research questions:

- Is the ontology model appropriate to capture and represent teachers' searching needs?
- Is the ontology perceived to be useful by the teachers in their seeking process?

Both research questions were answered positively. Regarding the first question, the study revealed that the TBS Ontology model captured and represented teachers' searching needs and expectations adequately. Study participants considered it clear and comprehensive and no major flaws were detected during the evaluation. As for the second question, the usefulness of the ontology was unanimously recognized, almost always with very positive comments from end users. Instances of usefulness were demonstrated in the way the ontology helped the seeking process by suggesting search terms and strategies for query formulation. Additional ways the ontology seemed useful to participants was in giving them a sense of what was available and

searchable by displaying the concept space of the collection, in prompting ideas on ways primary sources could be incorporated into lesson plans, and by inspiring ideas for learning activities.

Overall, the study findings were encouraging about the potential the TBS Ontology holds to help social studies teachers search for primary sources.

7.1. Discussion of Phase I Results

In Phase I, six in-depth interviews were conducted with North Carolina social studies teachers with the goal of gathering background knowledge to inform the design of the TBS Ontology. The review of the literature helped to frame the interview questions by indicating key issues in the context of history education, especially in relation to the use of primary sources in classroom instruction. The community of 6-12th grade social studies teachers was chosen because they represent the primary prospective end users of the TBS learning objects collection under development at the UNC-CH University Library. The outcome of the interviews revealed the complexity of the work context of social studies teachers and pointed out its implications for the search for and use of primary sources for teaching and learning. For example, the pedagogical requirements for inquiry-based teaching of history were largely constrained by the pressure of final testing. Furthermore, teachers had little time to plan and teach their classes, making it difficult to teach history through primary sources, even though such use promotes critical thinking among students. Moreover, the difficulty in finding good quality primary sources easily and quickly represented a major hindrance to fully exploit primary sources now openly available on the web.

Understanding this context was important for gaining insight on how the ontology should be designed in order to be most useful to the teachers. For example, teacher participants indicated that comparing and contrasting resources and relating historical content to students'

lives were important strategies to teach students interpretative skills. In addition, domain knowledge was elicited that served to indicate types of concepts and the appropriate level of specificity (e.g., education, school, one-room-school) and sets of relationships (e.g., familial relationships) the ontology should incorporate to support such tasks.

As mentioned earlier, the involvement of end users is rare in ontology development and is certainly a new practice in the early stage of ontology construction. Such an approach has proven to be particularly useful in this preliminary phase of ontology development for the richness and relevance of background knowledge collected. One reason for the effectiveness of the interviews' outcome may be due to the fact that the participants were all members of a specific user group that shares common work practices and information needs, resulting in the similarity of ideas and opinions they expressed. This helped to identify a rather clear set of requirements to be translated into specifications for the ontology. A more diverse set of end users with widely differing needs might not supply such uniform guidance, but would still be informative.

7.2. Discussion of Phase II Results

The nature of the domain of history, which is largely unstructured and interpretative, posed a major challenge. The lack of existing ontologies in this domain, at least in an open-access context, to serve as reference models and sources of reusable knowledge made it necessary to build the TBS Ontology from scratch. The development of the TBS Ontology followed METHONTOLOGY as the general methodology framework. However, two additions were introduced to the framework. The first one is represented by the interviews with teachers that helped to guide modeling decisions based on their expressed information needs and work practices. For example, feedback from the interviews encouraged the use of the teaching standards as an integrative source for knowledge acquisition.

The second addition to METHONTOLOGY was the evaluation of the ontology in the stage of prototype model, or seed ontology. While the use of conceptual models to elicit user feedback and evaluation is a rather common practice in software development (Beyer & Holtzblatt, 1998), surprisingly, it is not part of ontology engineering. The rationale for adding this step to the process was the assumption that a sound ontology model is the basis of an effective ontology implementation. More importantly, modeling is a critical task in ontology development and it is also the most challenging to perform. Gaining feedback on the validity of the model as well as on its potential helpfulness early in the process may result in an economical choice in that it can help to consolidate the model and build a better tool. If the results are not encouraging, they may suggest a major reconsideration of the purpose or scope of the ontology, more drastically, even an end to the project. Modifying the METHONTOLOGY procedures created a way of including information gained early in the process from end users and other sources that departed from the common engineer-centric view of ontology development where one size fits all. The background knowledge from the interviews suggested modeling decisions that contributed to make the model more adequate to the needs of its users. The outcome of the evaluation study provided a way to strengthen most of the modeling decisions as well as to receive suggestions on how to further improve it, as discussed next. Both steps contributed to streaming the process in that it is much easier and less expensive to make changes in the early stages of development than to modify a fully-implemented formal ontology.

7.3. Discussion of Phase III Results

Phase III was centered on the evaluation of the seed ontology. As discussed earlier, evaluation of ontology models is not a common practice in knowledge engineering, and is even more unusual when conducted from a user perspective. The main challenges of this phase of the

study were related to design issues such as evaluation criteria. Established sets of measures for ontology evaluation already exist, but they are typically employed for testing formal qualities of formalized ontologies (e.g., OntoClean (Guarino & Welty, 2002)). The aim of the study was instead to assess the quality of the ontology before going through the formalization process. The ultimate goal of the study was to validate the ontology model and to gather input on its potential usefulness. The study was qualitative and task-based. All tasks were framed in scenarios that were intended to represent real-world information-seeking problems (Carroll, 2002) in the form of a simulated work task situation (Borlund, 2003) (e.g., "Imagine that you need to prepare a class on the Great Depression and you would like to find some primary sources that illustrate various aspects of the historical period"). To make the scenarios realistic, they were based on the feedback gathered from the Phase I interviews and derived from the N.C. Standard Course of Study. The data was collected using multiple techniques, including demographic questionnaires, search and annotation tasks, post-task interviews, think-aloud protocols, and the researcher's observations and field notes.

The first task, which asked participants to perform Google searches, did not provide particularly useful data for assessing the ontology model as was originally expected. However, it revealed interesting aspects of participants' search strategies that may have implications for the future of domain ontologies in general, and the TBS Ontology in particular. Although the large majority considered themselves computer and Internet proficient with only one self-declared beginner, all participants showed limited capabilities to formulate or refine their queries independently. They all relied primarily on terms and phrases directly extracted from the task questions, as described in Chapter 6. Even when frustrated by the search results, they did not try to modify their queries by introducing, for instance, a new keyword. Instead, they mostly reformulated the queries by retyping the same words in a different order or by making slight

lexical modifications (e.g., from singular to plural). A few participants even entered the task questions verbatim.

The difficulty teachers often have in constructing search queries within digital libraries has been highlighted (Recker et al., 2004). The limited skills for formulating queries are a clear indicator of the need teachers have for tools that support and facilitate their searching. The results may also suggest that the teaching standards could prove to be a major provider of search terms. The role that educational standards play in lesson planning was highlighted both by the participants in various instances of this study and in the literature. It is reasonable to think that what the standards prescribe is also what is going to be searched, as one participant suggested during the session debriefing: "Because whatever terms appear there [in the standards], they are most likely going to be your search terms." These considerations further strengthen the idea that it is important to take teaching standards into consideration as a source of knowledge for the ontology and, even more generally, for indexing systems tailored to history teaching and learning at the grade level.

The second task asked participants to search the TBS collection with and without the use of paper-based facets. The analysis revealed a frequent use of terms from the facets to formulate or modify their queries and to stimulate a broader range of search strategies. Participants' feedback from post-task interviews revealed the facets were unanimously perceived as useful during the search process.

The usefulness of facets and directories to support web searching has been described in the literature. Benefits include providing context that shows relationships between topics, suggesting alternative query entries, and presenting new ideas and directions (Bates, 1989; Ellis & Vasconcelos, 1999; H. Lee & Olson, 2005). This type of support may, for instance, reduce the cognitive load and the time required for independently generating search terms because

recognition is easier than production (Kwaśnik, 2005). Also, by revealing the topical coverage of the collection, facets help users learn about the collection and "form a mental map of the subject areas that are covered and those that are excluded" that, as Shreeves and Kirkham (2004) suggest, would facilitate the seeking process.

Participants' feedback on the usefulness of the facets was indeed aligned with the literature. The facets were considered helpful to: a) formulate and/or refine queries by suggesting topics and terms that would not have occurred to them without the facets; b) focus their searches at the right level of specificity; c) provide an overview of the collection that made them aware of what was there and what was thus searchable; d) give ideas for teaching activities; and e) save time when planning a class. Participants expressed a general preference for having such a service available, especially for large and complex digital libraries like DocSouth.

The third task asked participants to navigate and annotate paper-based concept maps to simulate searches according to two scenarios. The design of this task was challenging due to the novelty of the approach taken. While graph-views of knowledge models are commonly used for task analysis, for example for knowledge elicitation in system development (Gordon, Schmierer, & Gill, 1993), in the context of this study they were employed for a different and more elusive purpose – to gather evidence of the appropriateness and usefulness of the ontology model. Indeed, the use of the maps revealed itself to be an effective means for the goal of the task. All participants were familiar with the notion of concept maps because they had used them in their classroom or in their pre-service training. Contrary to the researcher's expectations, minimal explanation of the task was needed and all participants seemed at ease with the requirements of the task. The use of the think-aloud protocol to accompany the navigation of the maps was key to generating accounts of participants' actions that were particularly informative and rich with detail.

The four upper-categories of the ontology (people, time, space, and domain-specific concepts) were targeted by all the participants in similar sequences and they appeared to be essential foci for the questions. Concepts and terms appeared to be those necessary to represent the domain and answer the task questions. No critical semantic gaps or structural incongruence were found. Some of the concepts/terms suggested by participants through annotations or verbal feedback filled holes in the clusters of concepts the researcher had intentionally left incomplete (e.g., additional ethnic groups and the judicial branch) to see if teachers would contribute suggested concepts/terms. It was also interesting to see that concepts such as "one-room school" derived from teaching activities described in the interviews and added reluctantly to the seed ontology were targeted by the participants. This revealed that such a level of specificity in modeling the category of education can be useful and appropriate. By thinking of the task questions in terms of competency questions, as proposed in Chapter 4, the ontology model seemed to be able to answer them in a satisfactory way. Annotations as well as protocols indicated that the level of specificity was aligned overall to the search needs of the participants. This was particularly clear for the geospatial and temporal dimensions as discussed in detail in Chapter 6.

The role teaching standards played in teachers' seeking process was highlighted again in this task. It was interesting to note that, even when participants were critical of the standards, they all agreed on the need to follow the standards' goals and objectives closely. An example was provided by the notion of "minority". Even the participant who expressed open disapproval about the way the notion of minority is employed in U.S. History teaching recognized the need to include it in the concept map since "that's something that teachers are going to be searching for."

7.4. Concluding remarks

The results of the study have suggested that the methodology adopted has guided the development of the TBS Ontology effectively. The method of construction enhanced by the users' contribution in background knowledge and feedback has well served the purpose of building a conceptual model that was both appropriate in terms of design features and potentially useful to the intended community of users. In particular, the evaluation study has provided a valuable method to assess the seed ontology showing the effectiveness of the use of concept maps. Finally, the study showed the potential value of the ontology to aid in searching and browsing the TBS collection as well as suggesting ideas about ways to use the collection to deliver social studies instruction. A question for future research is whether or not a user-centered approach to ontology development is scalable.

CHAPTER 8

CONCLUSION AND FUTURE DIRECTIONS

"All models are wrong, some are useful"
(Box, 1979)

This study was concerned with the potential of an ontology in the domain of history to facilitate the seeking process and ultimately the use of primary source materials for classroom instruction. Based on the assumption that an ontology, like any other knowledge model, is more effective when it integrates into its design the information requirements of end users, the study adopted a user-centered approach to the development of a domain ontology for the TBS collection of learning objects.

With the goal of building a semantic tool which would help connect a targeted set of users with the digital content they need, middle and high school social studies teachers were included in the development process of the TBS Ontology from the earliest stages. The rationale behind having end users participate early in the life cycle of the development process was to ensure that the system would be useful and begin to meet the needs and expectations of prospective users. Although this tenet may sound axiomatic, a user-centered approach is still rare within the context of digital libraries development and is even more rare in the field of ontology engineering. Typically, ontologies are constructed by knowledge engineers in collaboration with domain experts so involving end users in the development process was an unconventional choice.

The study began by conducting in-depth interviews with six teachers during the preliminary phase of the ontology design. Then the TBS Ontology was designed and its development reached the stage of conceptual model. This phase was followed by the evaluation of the ontology model by fourteen teachers.

The most significant result of the study was the evidence that the TBS Ontology was appropriate to support the information needs of its intended audience and was perceived as a useful tool for helping teachers in their seeking process. These findings were the results of an evaluation of the TBS Ontology that concluded the three-phase study. The interviews conducted in the initial phase of the study revealed aspects of the teachers' work context, as well as perspectives on the knowledge domain that were important for the construction of the ontology model. One of the major findings was the emergence of four upper-level categories represented by people, time, space, and domain-specific concepts that provided the conceptual framework for the model.

There is no doubt that conducting extensive analysis of potential end users would add significant time and effort to the already demanding process of ontology construction. In this instance, the significant and targeted contributions of the users guided the design of the ontology in an appropriate and focused direction, ultimately saving time and helping to create a more useful tool. There was general agreement and a shared acceptance of the world view offered by the ontology and the teachers, in large part due to the common teaching tasks required and educational standards followed. The reverse, of course, is also possible. That is, end users and ontology developers may not be able to find a shared conceptual framework. In those cases, the seed ontology evaluation step becomes even more crucial to determining whether it would even be possible to construct a useful ontology. It would force the designers to consider how to

accommodate the varying views of the end users in the ontology, something that is easier done at an earlier stage rather than a later one.

Such an approach may not be able to be generalized and must be considered on a case by case basis in relation to the size of the ontology being built, the nature of knowledge domain, and the type of end users targeted. Nevertheless, involving potential end users in a preliminary stage of ontology development appears to be a worthwhile endeavor for digital cultural heritage collections, including historical learning objects, where few domain-specific ontologies are available for reuse and whose subject matter is largely unstructured and highly interpretative.

The second phase of the study was concerned with the actual development of the TBS Ontology that produced an un-refined ontology model that was later evaluated. When building an ontology both manually and from scratch, the size of the domain to be represented is an important issue to take into account. The size of the TBS collection, which consisted of approximately 150 learning objects, turned out to be well suited as the main source of domain knowledge. The acquisition of knowledge could be carried out relatively easily and made it possible to adopt a bottom-up approach to ontology construction. Knowledge acquisition and domain modeling incorporated in various ways teachers' context of use of primary resources. As one of the tools that strongly influence history instruction, teaching standards were incorporated in the ontology development and revealed to be, as the evaluation findings later suggested, an important source of knowledge as well as of search terminology to be considered when developing domain ontologies in the context of grade level history instruction. Study results have implications for indexing practices and services that intend to provide a semantic approach to the annotation of historical digital resources for education to enhance access and facilitate inquiry oriented instruction.

To ensure the adequacy of the ontology before facing the technical challenges of formalization and implementation, an evaluation was performed on the seed ontology. This addition to the standard methodology carried three elements of novelty: the evaluation was conducted in an early stage of development rather than on the full-fledged ontology, it was designed from a user-centered perspective, and was performed with the use of novel techniques.

One of these techniques was the use of concept maps, unique from a methodological viewpoint for this context. The concept maps actually worked as a powerful means of communication, encouraging the teachers to express their thoughts, both verbally and via annotation, and offering useful feedback about the ontology as it was displayed on the maps. This experience may suggest a broader use of concept maps to collect data in user studies, especially with categories of users, such as teachers and students, who are familiar and feel particularly comfortable with this technique. Also, the effectiveness of concept maps in guiding the teachers through the concept space of the collection, suggesting domain-relevant connections and offering unexpected insights and ideas on how to use the collection, may encourage the display of concept maps on collections webpages as an introductory and instructional device.

An additional by-product of the evaluation study was the finding that teacher participants considered the facets, although presented on paper, very helpful to support their searches. This may suggest or reinforce for digital library developers the importance of considering a domain ontology to provide up-front search support for users, mostly likely in the form of faceted search services, in addition to being employed for back-end applications.

A secondary, yet important outcome from the study was the knowledge gained through the literature review, the interviews, and the final evaluation about the teaching and learning practices and information needs of an often overlooked community of digital library users:

middle and high school social studies teachers. This study contributes to the growing body of literature on teachers' use of digital libraries and primary source materials.

It must be acknowledged that the results of this study are limited and cannot be generalized because of the narrow focus on a segment of the domain of history. Another limitation is the degree of intrusiveness from the interviews, questionnaires, and task-based experiments that may alter the behavior of the subjects. For example, there were no negative comments to report. Although participants seemed to genuinely find the facets and the maps valuable, it is possible they were reluctant to express any criticism. Also, the number of study participants was constrained by practical issues, such as the availability of interested teachers in the vicinity. Moreover, the homogeneity of the study participants all coming from the same relatively small geographical area may prevent the generalization of the findings. Social studies teachers from other parts of the country may have different information needs and views of the domain of interest. An interesting extension of the study would be to conduct comparative studies with social studies teachers from other U.S. states and even countries as well as with history educators teaching within different levels of the education system.

More work needs to be conducted on developing the TBS Ontology for real-world application and further investigations are necessary to evaluate how effective the TBS Ontology is in the context of a working application. The results from the study encourage the continuation of the development process that can be done by refining and consolidating the seed ontology in light of teachers' feedback received during the evaluation and proceeding towards the production of a target ontology expressed in a formal representation language. Such an ontology would be one of the few developed in the domain of U.S. History at this time and could serve as a starting point for further expansions. As ontology research in the field of cultural heritage progresses, the

TBS Ontology may link or merge with similar developments and map into broader frameworks such as that provided by CIDOC CRM.

The findings of this study encourage more research on the construction of ontologies to support description and discovery of cultural heritage materials. The cultural heritage domain presents numerous challenges. One of the most daunting is related to the specific nature of the knowledge where concepts are often open to multiple interpretations, as in the case of history, and little ontological semantics is available for reuse. The experience gained in this study suggests that a bottom-up approach that focuses on a sizable collection like the TBS learning objects collection has a number of advantages. First, the construction of the ontology is likely to be manageable and thus more cost-effective. A domain ontology applied locally offers the immediate advantage of enhancing content discovery and use of the specific collection being represented. Moreover, in a large-scale perspective, the ontology has the potential to contribute reusable semantics that can be shared across applications. In a distributed, uncontrolled, and open environment like the web, the idea of a unique conceptualization is highly unrealistic and theoretically questionable. Different conceptual views on the same subject matter should be made possible by developing light-weight ontologies like the TBS Ontology.

This study shows that to make light-weight ontologies that are effective and useful is important to include the end user in the engineering process. Specifically, this study suggests that the conceptualization of a domain could be strengthened by factoring in users' requirements. As in the case of social studies teachers, the context of use in which teachers' information needs and expectations were framed was pivotal to shape the ontology model. The review of the literature and in-depth interviews represented effective methods that shed light on the types of constraints and work tasks specific to this educational community. Other user groups may require different methods of analysis. However, the role that complex and multidimensional use contexts play in

modeling a domain of knowledge represents a research perspective worth further investigations. To this extent, the use of concept maps can act as a powerful means of communication between developers and users.

"Ontologies are agreements, made in a social context, to accomplish some objectives" (Gruber, 2003). Aligned with this tenet, this study has proposed a notion of ontologies as the result of a sense-making process. An important methodological decision for this study was to seek the involvement of end users in order to reduce the risk of a subjective interpretation of the domain of interest and to help construct a tool that better reflects users' needs and goals and is ultimately more likely to be used**.** This study suggests that the involvement and the contributions of user communities to ontology development represent an area of research important to enhance communication between developers and users because "Ontologies are what they do: artifacts to help people and their programs to communicate, coordinate, collaborate" (Gruber, 2003).

Appendix I:

Phase I: Interview Questions

1. Tell me how you have used primary source materials with your students (e.g., lectures, class exercise, etc.). If you haven't, how would you like to?

2. Where do you search for primary source materials suitable for your class?

3. How often do you search for teaching materials and approximately how long does it take to locate the resources you need?

4. What were your most successful and the most frustrating experiences with searching teaching materials?

5. Have you used DocSouth? If yes, what has been your experience in using DocSouth? (e.g., perceived accessibility, quality of resources, amount of time required to find materials). If not, which digital collections do you use?

6. Describe for me how you search for digital materials (e.g., by topics, formats, concepts, time, events, geographic location, etc.).

7. Which type of content do you prefer to use (e.g., biographical accounts, letters, diaries, oral histories, photographs, etc.)?

8. How important are the NC curricular standards when you are searching for materials for your lesson?

9. Suppose you need to teach a lesson or series of lessons on the Great Depression. (Note: Different scenarios will be given according to what classes the teachers teach.) How would you go about searching for primary source materials that might support your lesson?

10. Given the previous scenario, in an ideal world what digital materials would you like to find and how would you like them grouped?

Appendix II:

Demographic Questionnaire

The following questions are designed to learn more about you, your teaching situation, and your school.

1. **Which of the following courses do you teach? Check all that apply.**

   _____ American history _____ World history _____ Geography

   _____ Economics _____ Government/Civics _____ Psychology _____ Sociology _____ English/Language Arts

   _____ Other (_____)

2. **Which grade(s) do you teach? Check all that apply.**

   _____ 6th _____ 7th _____ 8th _____ 9th _____ 10th _____ 11th _____ 12th

3. **Your Education level:**

Degree level*	**Major(s)**	**Minor(s)**
Associate		
Bachelors		
Masters		
Doctorate		

   * Completed / In progress.

4. **How many years have you been teaching social studies?**

   _____ years

5. **Your age:**

_____ 25 or younger _____ 26 - 30 _____ 31 - 40 _____ 41 - 50 _____ over 50

6. Your sex:

_____ Male _____ Female

7. Characteristics of your school

Location of your school (check one)

_____ urban _____ suburban _____ rural

Size of the student body (check one)

_____ small (under 500) _____ medium (500-1500) _____ large (over 1500)

How would you characterize the Socio Economic Status (SES) of the student population in your school?

_____ low SES _____middle SES _____ upper SES _____varied

Racial composition of the student body (check one)

_____ predominantly black _____ predominantly white

_____ predominantly Hispanic _____ multiracial

Do you have Internet access in your classroom?

____yes ____no

How many computers do you have in your classroom?

____

Do you have access to a computer lab in your school?

____yes ____no

Can you tell me approximately what percentage of your students has Internet access at home?

____%

8. Your computer expertise

_____ beginner _____intermediate _____advanced

9. Do you use primary source materials with your students?

_____yes _____no

10. If so, where do you search for primary source materials suitable for your class?

_____Web _____ personal collection _____ textbook ____library _____other

11. If you use the Web to prepare for class, what websites do you find most useful?

_____

12. Have you ever used Documenting the American South or other North Carolina digital collections?

____yes _____no

Appendix III:

Competency Questions

Imagine that you need to prepare a class on the Great Depression and you would like to find some primary sources that illustrate various aspects of the historical period.

1) Assess the impact of the Great Depression on the day-to-day life of a low income family in Virginia in the 1930s.

2) Analyze the effects of the New Deal policies on the Depression Era life of the women in North Carolina.

3) Identify the role of tobacco in the economic development of North Carolina in the 1930s.

4) Describe the differing impact of the Depression on various minority groups.

5) What was life like for children of your age in different areas of North Carolina during the Great Depression?

Appendix IV:

List of Terms Derived from Knowledge Acquisition

US Government (is_a)
Executive Branch (part_of)
President (part_of)
Franklin D. Roosevelt (is_a)
New Deal (proposed_by)
Program (part_of)
WPA; TVA; FERA; AFDC [Aid to family with dependent children = welfare] CCC; ... (is_a)
Legislative Branch (“US Government”, part_of)
Congress (part_of)
Legislation (“Congress”, passes/enacts)
Federal Law (part_of)
Fair Labor Standard Act (is_a; when; “Minimum Wage”, regulates)
Social Security Act (“Federal Law”, is_a; provides, AFDC; when, “1935”))
Judicial Branch (“US Government”, part_of)

Historical Period (begins; ends; has_event)
Civil War (is_a)
Reconstruction (“Civil War”, after; has_event, “Wall Street Crash”)
Industrial US
Modern US
Wall Street Crash (when)
Great Depression (“Reconstruction”, after; “Dust Bowl”, cause_of)
Dust Bowl (begins; ends)
New Deal (“Great Depression”, part_of)
World War II (“Great Depression”, after)
Postwar US (after)
Contemporary US (after)
Post 9/11

Person (xxx-living entity?)
  age
  birth_date
  death_date
  child(Person:"parent", Person:"child") (range: 0-12)
  adolescent (range: 13-29)
  adult (range: 20-65)
  senior (range: >66)

father(Person:"child", Person:"father")
mincardinality: at least one child
friend(Person, Person) symmetric
lives(Person, Place)
member(SocialGroup, Person; Family, Person)
mother(Person:"child", Person:"mother")
mincardinality: at least one child
name(string)
parent(Person:"child", Person:"parent")
sex(Person, *constant*: female, male) inverse
sibling(Person, Person) – owl:symmetric
spouse(Person, Person) – owl: symmetric
occupation(Person, Job)
work status (employed, unemployed) [employed=person with occupation]
social status (Person, xxx)
marital status (Person, Married, Non married, Divorced, Widow)

Economy
Services
Industry
Manufacturing Industry
Textile, …
Factory
Furniture Factory
Sawmill
Tannery
Cottage Industry
Tobacco Bag Stringing (is_a; “Hand labor”, type_of)
Agriculture
Farming
Crop (PlantAgriculturalProduct (SUMO)
Tobacco, Potato, Corn, Rye, Vegetables, Wheat, Cotton
Animals
Cows, Pigs, Hogs, Hens, Cattles
Farm
Land
Farm land

Employment
Employee (has_occupation; Type_by_Work_Status)
Labor
Labor Movement
Child Labor
Hand Labor
Cloth Washing, Sewing, Painting, Sweeping Floors, Tobacco Bag Stringing, Tobacco Bag Sewing …)
Job (OCCUPATION)

Bootlegger, Farmer, Mill Worker, Sharecropper
Stringing (type_of)
PRODUCTION
Factory labor (?)
Compensation
Wage
Minimum wage (hourly wage; equivalent_to)
Income (x year; greater_than, equivalent_to $1,000 (poverty threasold when 1939), less_than; has_source)
Salary (same_as;
Pension ("Income", source_of)
Insurance (Unemployment Insurance, Old-age Insurance) ("Income", source_of)
Means-Tested Welfare Programs ("Income", source_of)
Expense ("Income", inverse)
Grocery Bill, Medical Bill, Insurance, Taxes, Rent
Unemployment ("Employment", inverse_of)
(Work_status) Unemployed
MOVEMENT (One of 5 geographic standards)
Migration ("Unemployment", cause_of)
Internal Migration (LCSH)
Immigrant
Homeless / Hobo

Education
School System
Grade School
Middles School
High School
School Term (equivalent to 8 months after 1931)
School Building
One-room school

Transportation
By Foot
Car
Truck
Horse
Railway

Health
Health Condition
Disease
Rheumatism; Pneumonia; Mental disease, Pleurisy, Heart disease, Disability (crippled, deaf, blind…)
Medicare – Welfare/Unemployment

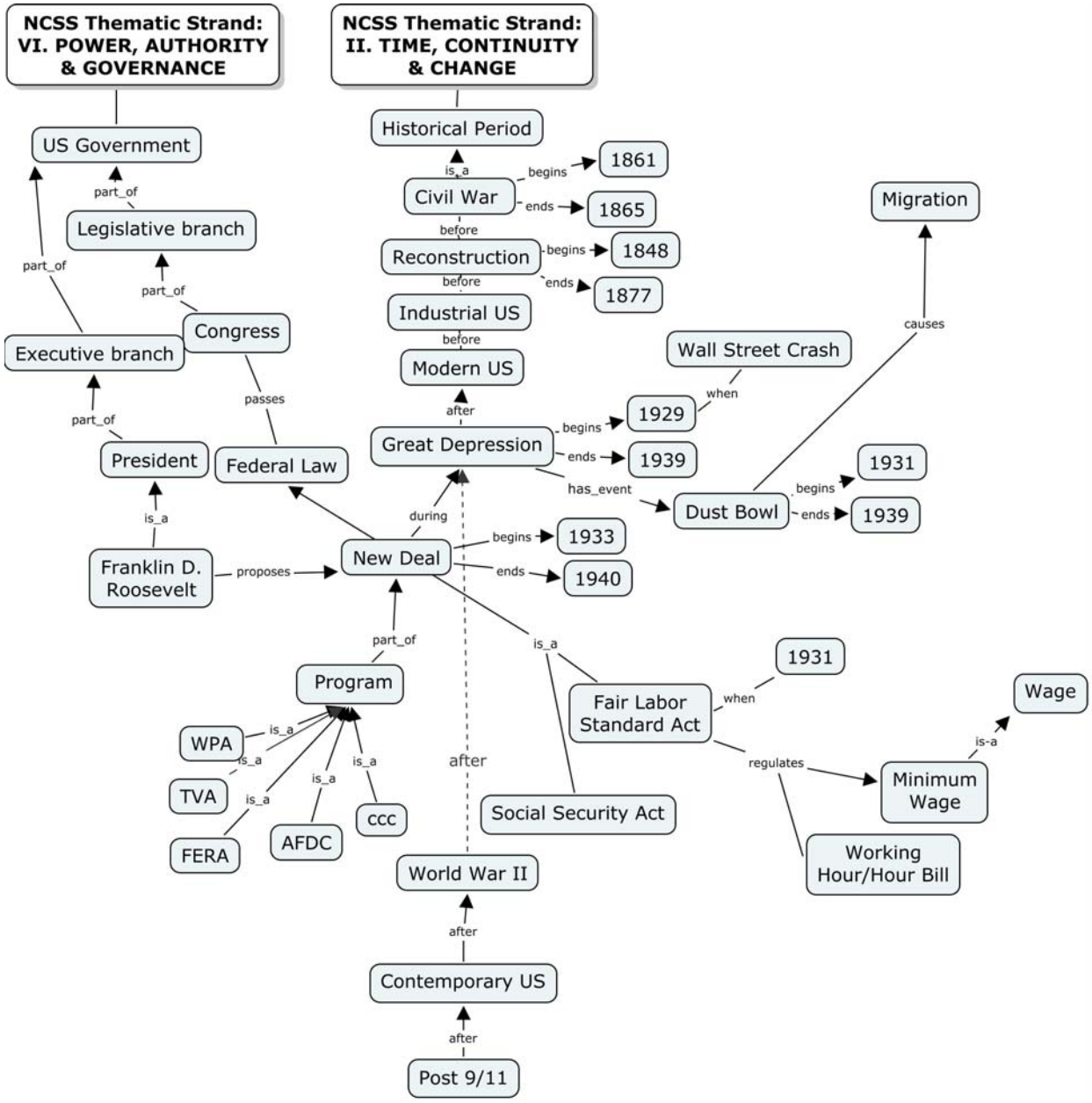
Home Condition

House
Running water (“House”, utility)
Electricity (“House”, utility)
Gas (“House”, utility)
Indoor Pluming (“House”, utility)
Front Porch (“House”, part_of)
Room (“House”, part_of; more_than #, equivalent_to #))
Furniture
Bed, Chair, Dresser, Table
Stove, Radio, Refrigerator
Cooking
Food
Groceries
Grocery Store
Grocery Bill (“Expense”, is_a)

Country
Regional Area (part_of)
State (“Country”, part_of)
State Region (part_of)
County (part_of)
Instantiated in:
USA
North, South, East, West, MidWest, …
North Carolina
Mountains, Piedmont, Coastal Plain
Virginia, …

Appendix V:

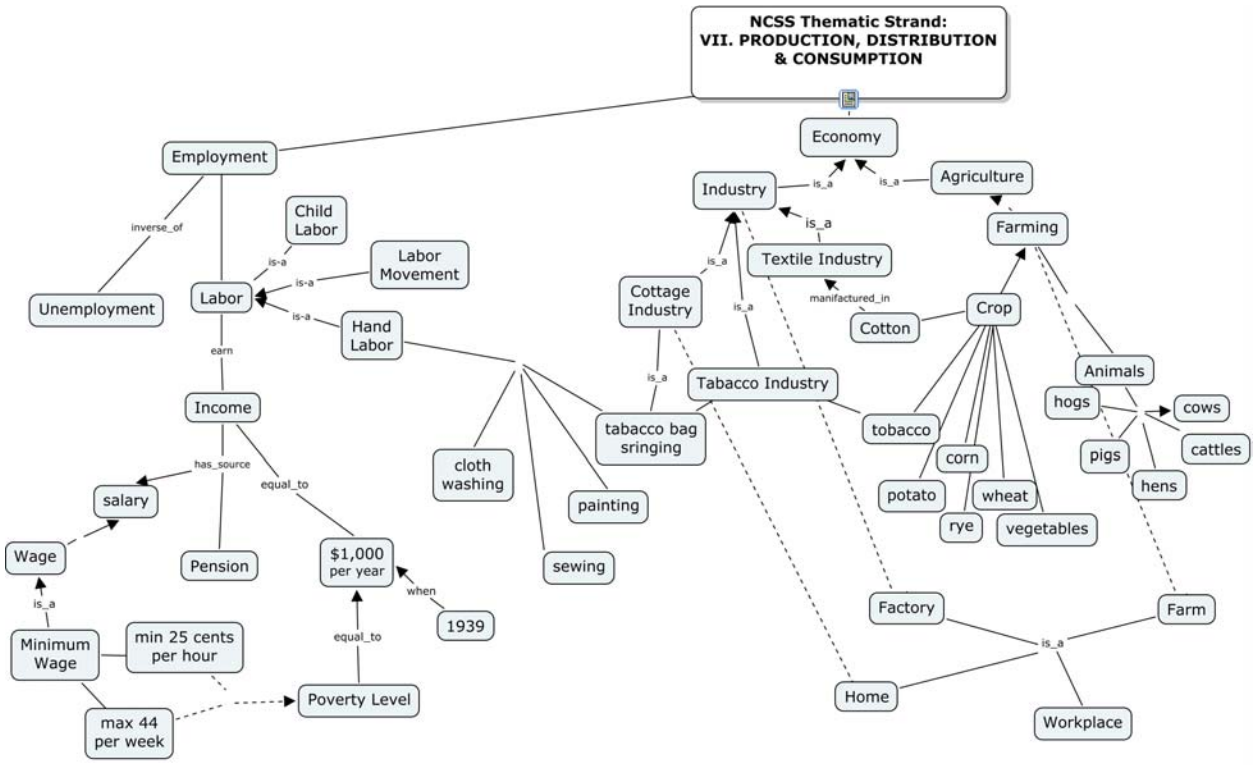
Concept Map: 1. Time



1. Time

Appendix VI:

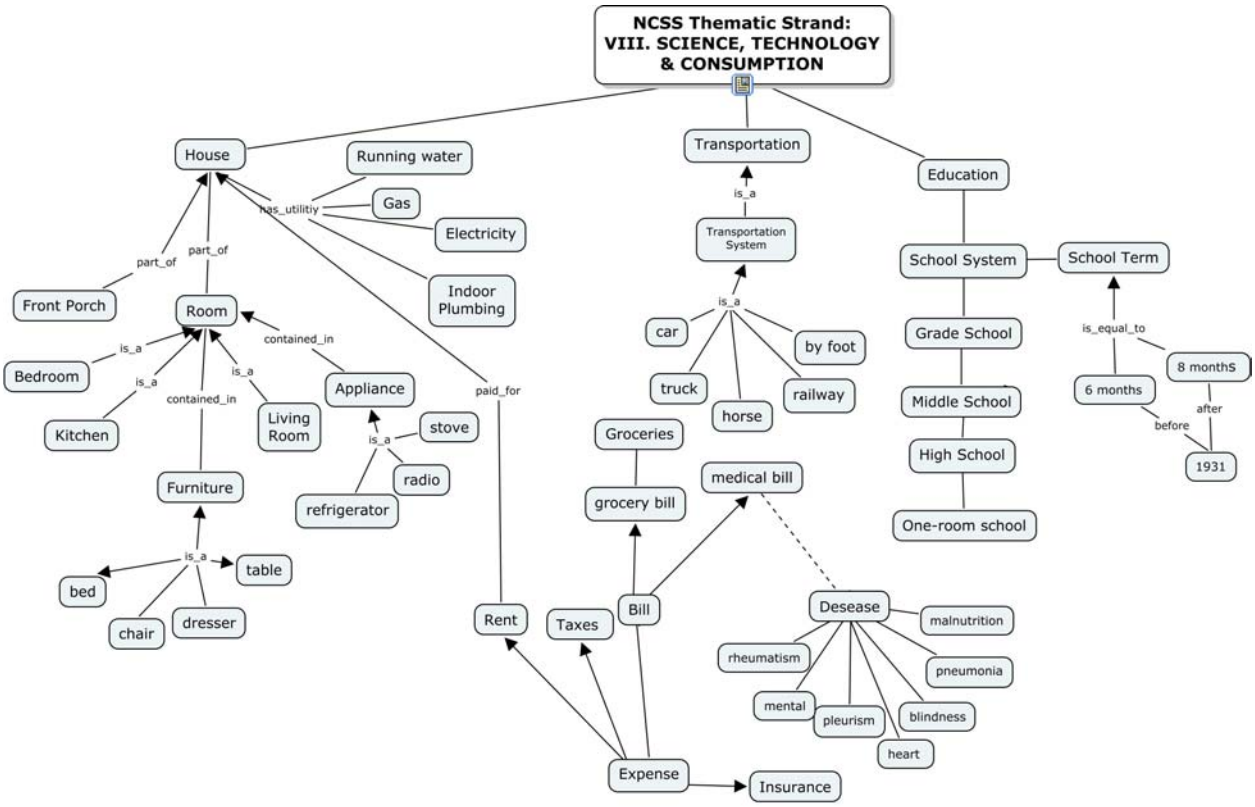
Concept Map: 2a. Domain Concepts



2a. Domain Concepts

Appendix VII:

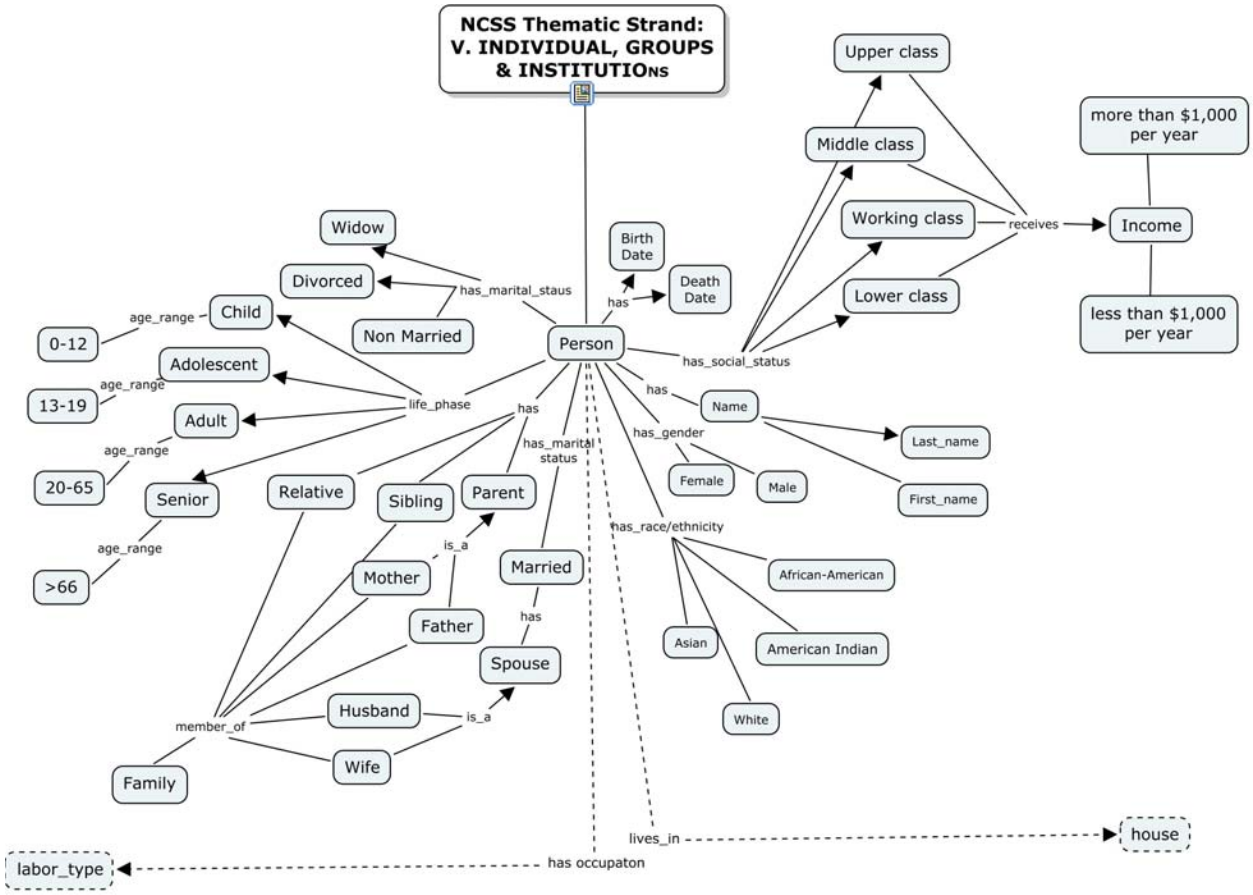
Concept Map: 2b. Domain Concepts



2b. Domain Concepts

Appendix VIII:

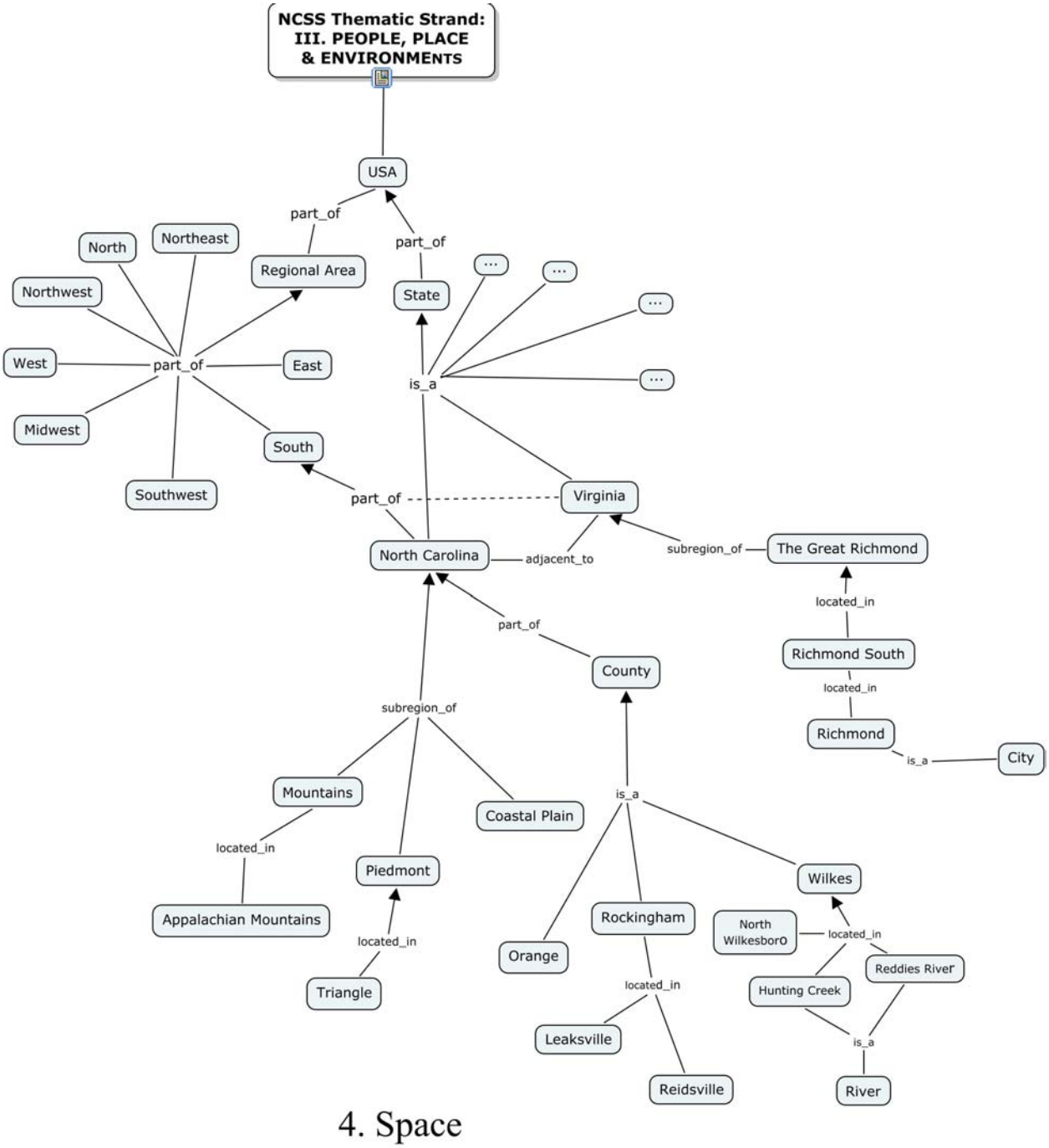
Concept Map: 3.People



3. People

Appendix IX:

Concept Map: 4. Space



4. Space

Appendix X:

Task 3: Debriefing Interview Questions

1. Are these maps clear and understandable?

2. Are the terms used the same ones you would use?

3. Would you use different words to express these concepts?

4. Would you connect the terms/concepts in a different way, or add additional lines? If so, what would they represent?

5. Are there historical events, types of people, places or other entities you could not find on the map and would have liked to?

6. Did you learn something that would be useful when searching or using the materials for your teaching? If so, what?

7. Would you like to use similar maps for a different collection of materials or a different time period?

8. Is there anything else about the maps you think I should know but haven't asked about?

9. Would using these maps would improve your search performance?

10. Would they address your searching needs?

11. Would they save you time and/or make it easy to do your job?

Appendix XI:

Study Script

1. Consent form. Thank you for agreeing to participate in this study. I will begin by asking you to read and sign a consent form.

2. Demographic questionnaire. Now I would like to ask you to fill out a brief survey of demographic information. It should take no more than five minutes.

3. Study overview. The study consists of three tasks. In the first task, you will be asked to perform an online search for primary source materials for a class on the Great Depression. In the second task, you will be asked to search again for primary source materials but this time using a specific digital collection. In the third task, I will introduce you to another way of exploring and searching for material without using a computer. At the end of each task you will be asked to comment on the experience. With your permission, I will audio-tape the session and, during the actual searching, I will screen-record your searches.

4. Study Directions
Task 1. On the paper I just handed to you, there are two questions related to the Great Depression. On the laptop computer, using the Web browser that is already open to the Google search page, please find some primary sources that satisfy each of the questions starting with the first question and proceeding in sequence. You can continue to search until you are pleased with the results, but try not to exceed ten minutes per question. I am interested in collecting the words or phrases you will be entering in the search box and, as you read on the consent form, your queries will be recorded automatically from the screen. <pause and observe during searches>

Now that you are finished, I'd like to ask you a few questions to help me understand your search process.

Task 2. Now I will show you a collection of digital primary learning objects at the UNC University Library: Tobacco Bag Stringing (TBS) <start at main page: http://www.lib.unc.edu/ncc/tbs/workers.html>. This is a collection of texts and images from the North Carolina Collection related to the impact of the New Deal on a cottage industry (tobacco bag stringing) in North Carolina and Virginia. Through the browse function <click browse function> I am going to show you a picture gallery of the collection. I am selecting picture #12 so you can see what I am referring to when I say "learning object". Now I am going to open the search page by clicking on "search selected collections". Next I am going to check "Tobacco Bag Stringing Operations in North Carolina and Virginia" from the search "select specific collections" menu and de-select the other options. In the search box I will enter the term "cotton" and look at the results of the search. Please spend a few minutes getting familiar with the website. I would be happy to answer any questions you might have. Please let me know when you are ready.

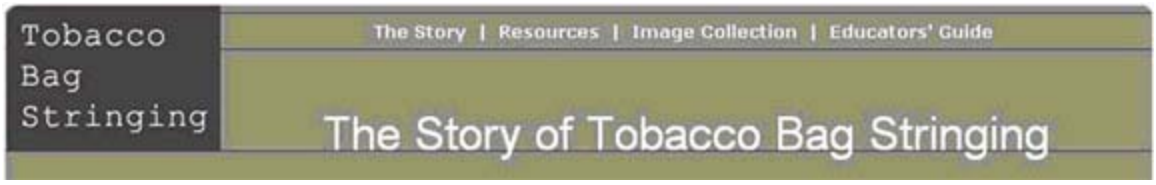
Now I would like to give you one question on paper. Please search the Tobacco Bags Stringing collection to find some learning objects that might be useful for your hypothetical class. Try to limit your search to about ten minutes. <pause while they search> Now that you are finished, I

will show you a piece of paper with a list of terms broken into three columns. Imagine than this is a web interface with facets or drop-down menus to search the collection. You probably have seen and used these types of search interfaces in the past. You could use these search facets for your next search. Please feel free to spend a few moments consulting this interface and looking through the facets to see what topics and subtopics are available. Once you have explored the facets, please repeat the search based on the same question. When you are finished, I will ask you a few questions to gain your feedback on the search experience.

Task 3. For the third and final task you won't need to use the computer. This portion of the session will be audio-taped. I am going to show you a five concept maps that represents the concepts and their relationships in the subject domain of the Tobacco Bag Stringing digital collection. As an example, I am going to simulate a search process based on this scenario: Imagine that you need to prepare a class on the Great Depression and you would like to find some primary sources that illustrate the following aspect to your students: 'What was life like for children of your age in different areas of North Carolina during the Great Depression?'- I am going to walk you through the concepts and the relationships between the concepts and draw in pen paths to illustrate how a search process can be guided or constructed using a concept map.

Next, I will give you two of the questions you have used before, once at a time with a set of unmarked diagrams and some colored pens. With the goal of answering these questions, as you did in task 1 using Google, I want you to manually navigate the concept map and show your exploration and seeking processes. For each question, you should draw your search path(s) through the links between the concepts and mark the concepts you would select as search terms. Please describe aloud, during the entire session, what you are doing and why. Also, I encourage you to annotate the maps and write down any questions, concerns, or suggestions you might have. For example, you may propose different or additional concepts, terms, and/or concepts connections. When you are finished, I will ask you a few questions to help me understand your choices and actions <pause during task> The study ends after this debriefing interview.

Appendix XII. Paper-based Search Faceted Interface



PEOPLE
Woman
Man
Child
Adolescent
Adult
Senior
Married
Non Married
Divorced
Widow
Family
-member
--father
--mother
--sibling
Race
-African American
-American Indian
-Asian
-White
Social Status
- Upper class
- Middle class
-Working class
-Lower class
Working Status
-Employed
-Unemployed

HISTORICAL PERIODS
Civil War
Reconstruction
Industrial US
Modern US
Great Depression
New Deal
-Program
--AFDC
--FERA
--TVA
--WPA
-Legislation
--Fair Labor Standard Act
--Social Security Act
World War II
Postwar US
Contemporary US
Post 9/11

EVENTS
---Wall Street Crash
--- Dust Bowl

PLACES
USA
-North
-South
--North Carolina
---Mountains
----*county*
---Piedmont
----*county*
---Coastal Plain
----*county*
--Virginia
-East
-West
-Northeast
-Southeast
-Northwest
-Southwest
-Midwest

LABOR
Labor Movement
Child Labor
Hand Labor
--Cloth Washing
--Painting
--Sewing
--Sweeping Floors
--Tobacco Bag Stringing
Working place
--Factory
--Sawmill
--Tannery
Jobs
--Farmer
--Mill Worker
--Sharecropper
--Stringing
Income
-source of
--Insurance
--Means-Tested Welfare Programs
Programs
--Pension
--Salary
---Wage
----Minimum wage
Expense
-source of
--Grocery Bill
--Insurance
--Medical Bill
--Rent
--Taxes

ECONOMY
Industry
Services
-Manufacturing Industry
---Textile
---Furniture
-Cottage Industry
---Tobacco Bag Stringing
Agriculture
Farming
Crop
Animals

MOVEMENT
Migration
-Emigration
-Immigration

LIVING CONDITIONS
Education
School System
--Grade School
--Middles School
--High School
--One-room School
-School Term

Transportation
Transportation Means
-Car
-Horse
-Railway
-Truck
-By Foot

Health Conditions
Disease
-Disability
-Heart disease
-Malnutrition
-Mental disease
-Pleurisy
-Pneumonia
-Rheumatism

House
-Front Porch
-Room
--kitchen
--bedroom
-Furniture
-Appliances
---stove
-Housing Condition
---Electricity

---Gas
---Indoor Plumbing
---Running water

Appendix XIII:

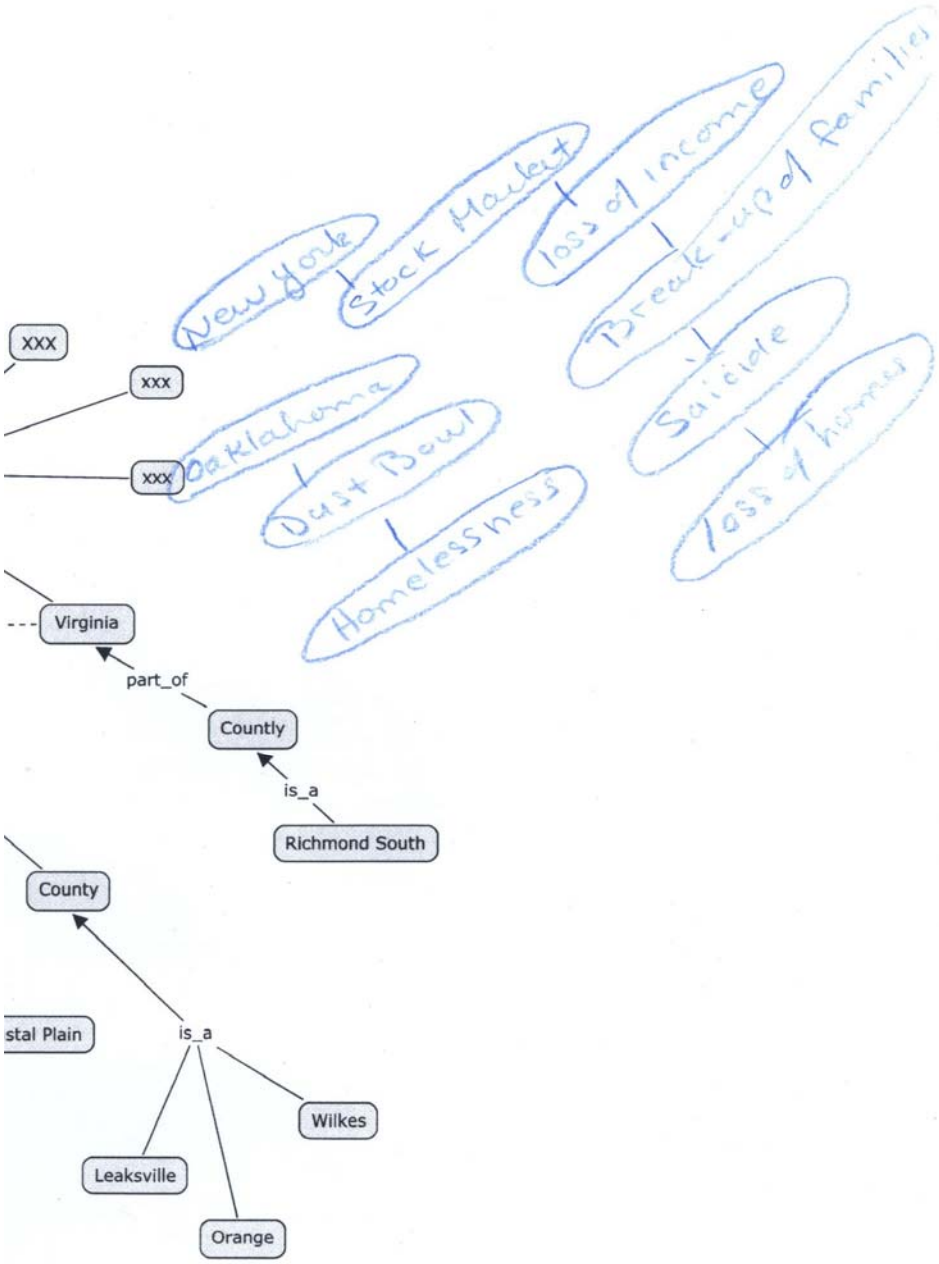
Task 2: Debriefing Interview Questions

1. Did you find the facets helpful?

2. If yes, in what way were they helpful?
   - Did they suggest new terms (more appropriate, more correct, more specific, etc.) to reformulate your query? Please explain.
   - Did they give you hints on new search possibilities or unforeseen perspectives on the collection domain?
   - Other ways?

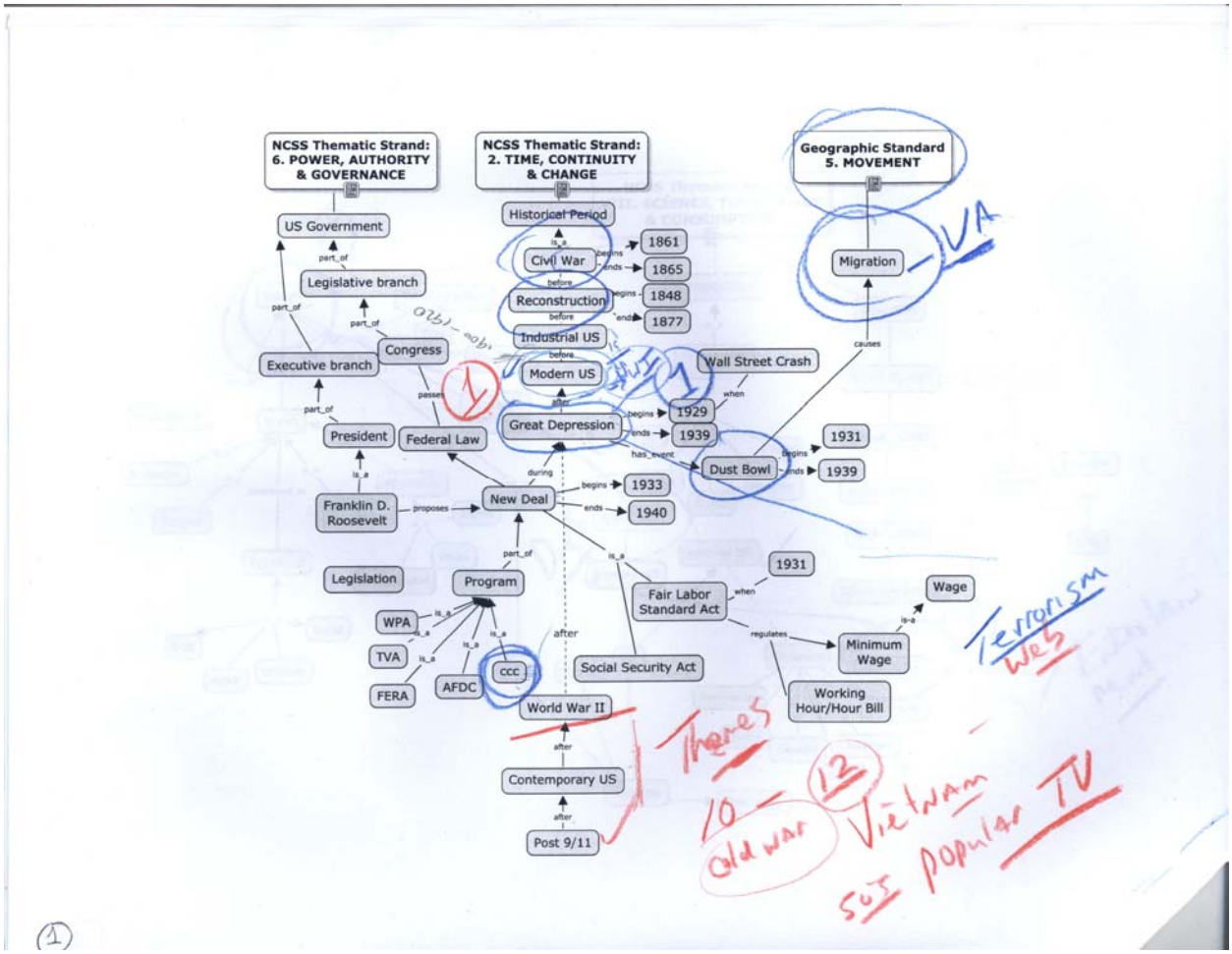
3. If no, in what ways were they not helpful?
   - Did they suggest terms that were not relevant to your search? Please explain.
   - Did they not provide the kind of terms you would use if you were searching?
   - Other ways?

Appendix XIV. Teacher's annotated concept map for "impact of the Depression" for Question 1



Appendix XV:

Teacher's annotated concept map for periodization for Question 1



Appendix XVI:

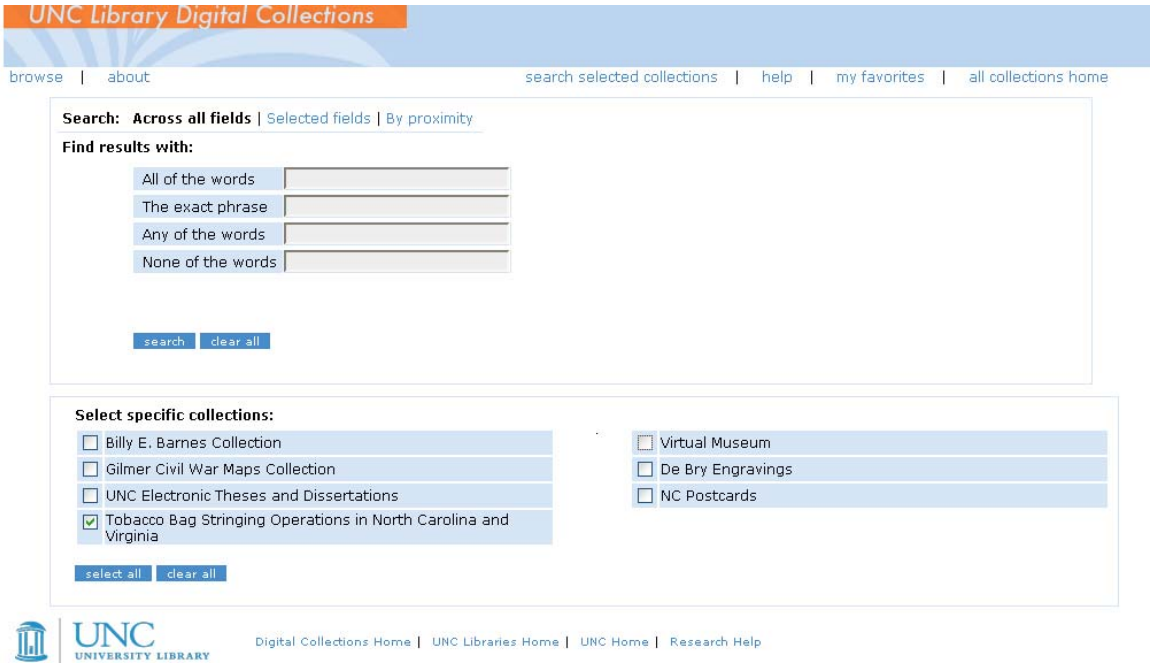
List of participants' concepts/terms suggested or derived from queries during the three tasks of Phase III.

Concepts/terms suggested by participants		
Task 1	**Task 2**	**Task 3**
Rural	Culture Development Eastern (North Carolina) (tobacco) cultivation (tobacco) product Money Education* Poverty*	Apprentice Break up Of Families Chinese College Compensation Eastern (North Carolina) Farm as a Workplace Farming Communities Hispanic Homeless Homelessness Internship Irish Italians Judicial Branch Latino Americans Loss of Income Loss of Status Minority Oklahoma Rations Recreation Rural / Urban Russians Suicide Trade School Wheat

* Not displayed on the facets, but included in or derivable from the concept maps.

Appendix XVII:

Search interface of the TBS collection.



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