Modeling a Domain Ontology for Cultural Heritage Resources: A User-Centered Approach

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The use of primary source materials is recognized as key to supporting history and social studies education. The extensive digitization of library, museum, and other cultural heritage collections represents an important teaching resource. 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 Library of the University of North Carolina at Chapel Hill. During a three-phase study, an ontology model was designed and evaluated with the involvement of social studies teachers. 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 collection access. The primary contribution of this study is the introduction of an approach to ontology development that is user-centered and designed to facilitate access to digital cultural heritage materials. Such an approach should be considered on a case-by-case basis in relation to the size of the ontology being built, the nature of the knowledge domain, and the type of end users targeted.

Introduction

While a great deal of attention has been paid to ontology development in recent years, especially in the context of the semantic Web, building ontologies remains a challenge in regard to both design and implementation. Ontologies represent agreed domain semantics. Modeling a domain is a critical component of the ontology building process. Developers are responsible for making choices that will impact the effectiveness and ultimately the usefulness of the tool. A possible target for domain ontology development is the vast and impressive collection of cultural heritage materials that libraries, archives, and museums have spent the past few decades digitizing. These individual collections are a rich source of instructional material for history teachers and are fundamental to a strong, inquiry-based social studies education. Nevertheless, they remain largely underused by the education community, partially because of the challenge of accessing and selecting digital primary sources appropriate for classroom instruction. Although still scarce if compared with the wealth of digital content available, new discovery tools and support services are emerging to facilitate discovery and use of such resources. Among those tools, ontologies are gaining increasing attention for their potential to improve functionality and, more specifically, to facilitate subject access to digital content (Greenberg, & Méndez, 2009; Kruk & McDaniel, 2009).

Is it possible to design an ontology with any assurance that it will be useful to the end users it is intended to support? With this research question in mind, this study investigates a user-centered approach to the development of an ontology for the domain of history. To test this hypothesis, the researcher chose a small collection of primary source materials digitized by the University Library of the University of North Carolina at Chapel Hill (UNC-CH) for research and instructional purposes. The study also focuses on only one of the intended audiences for the collection—middle and high school social studies teachers. It is suggested that 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 resources. The primary aim of this study is to confirm whether or not an ontology designed from a user-centered perspective is ultimately more useful in meeting the needs of a digital collection’s intended audience.

Literature Review

Digital primary source materials are increasingly valued as educational resources that support effective strategies for inquiry-based teaching and learning (Coventry & Bass, 2003). 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). 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, & Marlin, 2003). The wide range of uses that cultural digital collections may enable and support, and the variety of user communities that may benefit from these collections, make it important to rethink how these materials are discovered, presented, and used. As Borgman et al. (2005) point out, tools and services to facilitate school educators in their teaching and learning practices are still very scarce if compared with the wealth of digital content available to them. Tailoring digital collections to their intended communities of users—“customization by community” in Lynch’s words (2003, p. 196)—can be the key to bridging the distance between users and resources.

The limitations of traditional knowledge representation and organization methods are seen as a major impediment to the discovery of and access to digital collections. In general, libraries have treated digital materials as they have treated the physical information objects under their stewardship, that is, by cataloging them with descriptive and semantic standards designed for traditional search and retrieval methods. The shortcoming of this approach has been particularly confounding for collections of digital cultural heritage materials, the content of which poses unique challenges to its representation (Baca, Harpring, Lanzi, McRae, & Baird Whiteside, 2006). The limitations of subject access in online library catalogs have been extensively analyzed and described in past studies (Sridhar, 2004; Fischer, 2005). One of the major factors reducing the effectiveness of subject searches is the difficulties users have in formulating subject queries that match the Library of Congress Subject Headings used by most academic libraries (Larson, 1999). The necessity to develop alternative subject access tools has long been recognized (Lancaster, Connell, Bishop, & McCowan, 1991). The integration of library catalogs with other discovery tools that would complement and possibly augment or enhance current subject access has been at the center of recent discussions on the future of cataloging (Calhoun, 2006; Coyle & Hillmann, 2007, Library of Congress, 2008). The usefulness of semantically enriched and domain-specific metadata to improve digital cultural heritage resource discovery and retrieval has also been explored, leading to a growing interest in applying semantic Web technologies to cultural heritage collections of materials (Benjamins et al., 2004; Hyvönen, 2009).

Ontologies are seen as a possible solution for improving discovery and access to digital content and as such have become an emerging area of study in the field of digital library research (Greenberg & Méndez, 2009). The potential of semantic technologies, ontologies in primis, for improving digital library functionality and facilitating interoperability, sharing, and reuse of knowledge across repositories is the focus of a series of research projects. The notion of a semantic digital library is beginning to emerge (Sure & Studer, 2005; Kruk & McDaniel, 2009). Fast and Campbell (2001) discuss the usefulness of ontologies for providing more granular access to digital content and enabling content aggregation based on the needs of the users. Within the field of education, the roles that ontologies could play have also generated a growing body of research, especially in the area of e-learning (Naeve, Lytras, Nejdl, Balacheff, & Harding, 2006). The need for 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 a matter of concern for several years.

As the literature suggests, ontologies and ontology-driven metadata have the potential to significantly enhance information systems, including digital libraries and educational applications. 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, primarily as the key infrastructure to enable the semantic Web, real-scale applications are 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. DeRidder (2007), who discussed various applications of ontologies in digital libraries, stresses the need to carefully weigh issues of feasibility, scalability, and usefulness in relation to cost and effort required to create ontologies for digital libraries. The range of benefits that ontologies may offer has to be considered in light of the technical challenges that the development of such tools poses. The cost benefits of ontology development are not yet known (Bontas & Mochol, 2006), especially for manually constructed ontologies that are typically labor-intensive and error-prone (Ding & Foo, 2002).

Building ontologies for information systems “remains an arcane art form” (Guarino & Welty, 2002, p. 61). 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 standards comparable to ISO standards for ontology development. Ontological engineering, the discipline applied to ontology development and use, is relatively young, especially compared with more established fields such as software engineering or knowledge engineering (Fernandez-Lopez, 1999). As a result, ontological engineering does not yet have a solid set of methodologies based on proven principles. In recent years, an increasing number of studies have focused on methodological issues (Bouaud, Bachimont, Charlet, & Zweigenbaum, 1995; Gruber, 1993; Mizoguchi, Vanwelkenhuysen, & Ikeda, 1995; Noy & Hafner, 1997; Noy & McGuinness, 2001; Uschold, 1996; Uschold & Gruninger, 1996). Several of these studies have attempted to define principles that would systematically guide the development of ontologies. Others, such as Fernandez-Lopez and Corcho, Fernandez-Lopez, and Gomez-Perez (2003), simply offer extensive overviews of methodologies for ontology construction, while still others, like Beck and Pinto (2002) and Pinto and Martins (2004), analyze and compare the most representative methodologies, techniques, and guidelines. It has been argued that a unified ontology engineering process that is
flexible and extensible enough to enable developers to adopt and combine different components appropriate for different application scenarios is needed (Simperl & Tempich, 2006). One of the most comprehensive and well-established methodologies used for constructing ontologies is Methontology, which offers a general framework that defines design criteria, practices, activities, and tools for ontology engineering. Methontology was developed by the Laboratory of Artificial Intelligence of the Polytechnic University of Madrid, and it is based on a real-world ontology-building application in the chemical domain inspired by knowledge engineering techniques (Fernandez-Lopez, Gomez-Perez, & Juristo, 1997).

The conventional model of ontology design and construction is system-oriented. Typically, knowledge engineers, who make their own interpretations of the knowledge to be formalized, build ontologies. Domain experts may be involved in the process, but end users are typically excluded from the entire lifecycle of ontology development. Although the user-centered approach is broadly adopted in system development as a strategy to improve system usefulness and usability and to overcome the limitations of traditional system-centered design (Gould, Boies, & Lewis, 1991; Mao, Vredenburg, Smith, & Carey, 2005), ontology development methods that factor in end users are not common. Only a handful of studies have addressed this approach. Holsapple and Joshi (2002) conducted one such study. They present 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). This approach is shared by Mizoguchi (2003), who argues that “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). Consulting with members of the intended audience is central to developing a domain model that best reflects the mental model of the community. For example, one of the keys to the success of the gene ontology (GO) lies in its construction from within the biology community rather than from external knowledge engineers (Bada et al., 2004).

Study Overview

This study investigates methodological issues concerning the design of an ontology in the domain of history, specifically a segment of U.S. history. Based on the assumption that a domain ontology can better serve its function when it is designed with the end users in mind, the study proposes a process for constructing an ontology that involves the participation of the intended community of end users during the design stage of the process. Toward this end, a prototype ontology model was designed for a collection of digital primary sources and later evaluated with the participation of social science teachers, who represent one set of potential users of the chosen collection.

A collection of digital primary materials from the UNC-CH university library provided the knowledge domain for the ontology and served as the testbed for the study. The collection, entitled “Tobacco Bag Stringing” (TBS), describes the lives of individuals and families, in the tobacco-growing regions of North Carolina and Virginia, who are 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). 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 university librarians had created the TBS collection primarily, although not exclusively, to facilitate teachers’ access and use of the library primary sources in the context of a broader project intended to repurpose their digital content for educational purposes. Once fully developed, the TBS ontology would serve as an indexing tool to provide semantically enhanced annotation of the digital content of the collection.

The TBS collection represented an ideal subject for the study. First, the digitized primary source material covers an important historical period, the Great Depression and the New Deal era, both of which are well-suited for a variety of instructional objectives. Further, it reflects a defined and manageable segment of the knowledge domain to be modeled. Finally, the UNC-CH university library staff was interested in and supportive of exploring innovative methods of making their digital collections more accessible to the education community.

For the purposes of the study, an initial prototype ontology model was designed. The design process was carried out using Methontology, the ontology engineering methodology discussed earlier. Methontology uses an iterative process based on evolving prototypes. The process consists of a series of activities required for constructing and maintaining ontologies that encompasses the entire lifecycle of the ontology. These activities are as follows: specification, knowledge acquisition, conceptualization, formalization, integration, implementation, evaluation, documentation, and maintenance. Notably absent from the process, however, is the perspective of the end users. To factor in the user perspective and translate it, whenever possible, into a set of design requirements, the study introduced two new steps or subactivities to the ontology engineering process intended to be performed during the design phase. The two methodological additions are illustrated in Figure 1 and include:

- a preliminary user study conducted in the form of personal in-depth interviews and
The design of the model was informed by the background community of end users. The ontology and its usefulness as perceived by the intended type that was conducted to assess the quality of the design of the model before the formalization activity.

The first addition to the methodology is represented by a user study conducted through a series of individual interviews with representatives of the intended audience of the ontology-enhanced collection. The purpose of this activity was to collect background information about the needs, working practices, knowledge level, and expectations of the end users to inform the design of the ontology. The second addition is the evaluation of the ontology at the stage of model prototype. The evaluation is performed from the perspective of end users and is conducted to review and strengthen the model before the formalization activity.

Research Questions

Based on the assumption that the TBS ontology can better serve its target audience if the perspective of the intended end users in terms of work practices, searching needs, and level of knowledge is considered during the design process, the study addresses 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?

Study Design

To address the research questions, the study comprised three phases as follows.

Phase 1 is a set of interviews intended to investigate social studies teachers’ instructional practices, information needs, tasks and expectations and that was conducted to gather background information to help determine whether an ontology would be helpful and what kind of ontology would be preferred. This phase involved semistructured 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.

Phase 2 is an ontology model that was designed to represent a subdomain of North Carolina History and reflects the subject area of the TBS collection of digital objects. The design of the model was informed by the background information gathered in phase 1. The development process included the following activities: specification, knowledge acquisition, and conceptualization. The outcome of this phase was a model prototype that was further tested by end users in the third phase.

Phase 3 is a user-centered evaluation of the model prototype that was conducted to assess the quality of the design of the ontology and its usefulness as perceived by the intended community of end users.

Phase 1: Study of the End Users

Methodology

In phase 1, six in-depth interviews were conducted with middle and high school social studies teachers 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. An extensive review of the literature helped to frame the interview questions by indicating key issues in the context of history education and the use of primary sources in classroom instruction that should be addressed. The goal of the interviews was to contextualize the teachers’ experience using or attempting to use digital primary materials in the classroom to help determine whether an ontology would be useful and, if so, what kind of ontology would be preferred.

Participants

Six social studies teachers from high schools and middle schools throughout Orange, Durham, and Wake Counties in North Carolina participated in the study. Only participants who had used digital primary resources were invited to participate. The researcher explored issues surrounding the search for, and use of, digital primary source materials in the classroom. Subjects were recruited by direct solicitation through an e-mail sent to the list of participants in the UNC Library’s Documenting the American South (DocSouth) Summer Institute 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. The pool of participants was evenly distributed by sex and their ages ranged from 25 to 50+ years. Likewise, their teaching experience varied, from 1 to 29 years. All had additional advanced degrees in history and education. They 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 but one had Internet access in their classrooms.

Procedures

The interview protocol included 10 questions about how teachers use primary sources in the classroom, how they search and find primary sources, and the broader context of their teaching of U.S. history. The semistructured format of the interviews allowed specific questions and topics to be addressed 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. Interviews were audio-recorded and later transcribed.
Findings

Although limited in scope, the responses from the six participants offered a clear view of the type of resources social studies teachers need, what they are able to find and not find, and what they would like to find. Their comments revealed how primary sources were integrated into the classroom and described the strategies they adopted to apply current pedagogical principles to cope with institutional constraints.

The main themes that emerged concerned the teachers’ general use of primary sources, the role of educational standards and standardized testing in delivering instruction, and the search strategies, habits, problems, and expectations of the teachers. A summary of the interview findings is presented below.

- Teachers generally have a positive attitude about technology, and 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, instruction, and sources, from which guidance for the discipline content and the pedagogical approach to the subject matter are derived.
- 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 a more powerful means to engage students than textual materials.
- 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 to make connections between students’ lives and the lives of people from the past. Students relate better to materials that show or describe individuals their own age.

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, select, and use digital library content for instruction. Such contextual information helped to identify instructional scenarios and tasks or activities in which an ontology would help the seeking process and add value to the search system. 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. Moreover, feedback from the interviews encouraged the use of the teaching standards as an integrative source for knowledge acquisition. One of the main tenets that emerged is that people, time, space, and domain-specific concepts are central dimensions in teaching history. Teachers’ input was then utilized to inform the ontology design process, especially regarding decisions on how to model the domain knowledge of the collection.

Phase 2: Design of the Ontology Model Prototype

Methodology

The development of the TBS ontology followed Methodology as the general methodology framework. As discussed earlier, two additions were introduced to the framework. The first was represented by the interviews with teachers that helped to guide modeling decisions based on the teachers’ expressed information needs and work practices. The second addition was the evaluation of the ontology prototype model performed in phase 3. What follows is the description of the activities involved in the design of the TBS ontology model. Because this study focuses on the design process with the aim of modeling a prototype to be later evaluated, only the activities specifically focused on the design component of the development process are addressed, including specification, knowledge acquisition, and conceptualization.

Specification. The specification phase includes the definition of the purpose and the scope of the ontology. As discussed earlier, the general purpose of the TBS ontology is to facilitate access to and ultimately use of the TBS 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 collection.

The scope of the ontology primarily reflects the knowledge domain or subject matter covered by the TBS collection. The TBS ontology is domain-specific, as domain ontologies are viewed as suitable sources of semantics for describing Web resource content. In ontological engineering, one of the methods for defining the scope of the ontology is based on the use of competency questions that 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. Competency questions are typically formal and are intended to verify whether the ontology contains a necessary and sufficient set of axioms to represent and solve competency questions (Gruninger & Fox, 1994). However, they can also be informal and intended to be answered by the ontology on the basis of motivating scenarios (Pinto & Martins, 2004). Formulated at the beginning of the development process, they 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 (Noy & McGuinness, 2001). In the context of this study, informal competency questions and motivating scenarios were derived from teachers’ real-world examples described during the in-depth interviews. 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 3 of the study.

**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 the following aspects of the historical period:

- Assess the impact of the Great Depression on the day-to-day life of a low-income family in Virginia in the 1930s.
- Analyze the effects of the New Deal policies on the Depression Era life of the women in North Carolina.
- Identify the role of tobacco in the economic development of North Carolina in the 1930s.
- Describe the differing impact of the Depression on various minority groups.
- What was life like for children of your age in different areas of North Carolina during the Great Depression?

**Knowledge acquisition.** Knowledge acquisition was performed manually because of the small size of the ontology prototype and the amount of relevant nontextual 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 earlier. The textual content of the digital collection 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 it provided the basis for the TBS collection. Several knowledge organization systems were consulted in developing the TBS ontology including WordNet and the Getty Thesaurus of Geographic Names (TGN). Lexical resources like WordNet are helpful in capturing the nuances of the language, providing both generality and consistency (Guarino, 1997). For this study, WordNet proved to be a useful reference tool for suggesting concepts to be manually incorporated and to help frame the ontology structure. The TGN also provided a useful reference tool for standardized place names 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), history Web sites (e.g., The New Deal Network), and lesson plans from educational Web sites (e.g., LEARN NC) as suggested by interviewees and faculty at the UNC School of Education. Reuse of existing knowledge was limited because of a lack of suitable sources. Although the number of ontologies in electronic form and the services to facilitate the discovery of Web-based ontologies 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 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, 2010). Developed within the museum community, CIDOC CRM has the broader goal of enabling a semantically enriched information exchange between museums, libraries, and archives (Gill, 2004). Although not a direct source of knowledge for the TBS ontology, CIDOC CRM was viewed as an appropriate overarching framework where a full-fledged TBS ontology could be linked and related to other germane domain-specific ontologies.

The knowledge elicited during the user study in phase 1 was an integral part of the knowledge acquisition development phase. 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. They offered input on areas of knowledge domain and perspectives they find important when delivering instruction. For example, teachers indicated clusters of domain concepts and themes that they consider essential or useful in teaching U.S. history and the Great Depression (e.g., what was it like to attend school in North Carolina during the Great Depression). 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). One of the main tenets that emerged from the user study was that people, time, space, and domain-specific concepts are key elements in the teaching of history. These dimensions served to shape the conceptual structure of the ontology and were translated into a core of upper-level categories that provided the foundation for the ontology knowledge framework. The outcome of the knowledge acquisition process, including the knowledge elicitation phase, was a list of terms and candidate concepts

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and their relationships. Once the terms were identified, the next step was to address the conceptualization underlying the terms.

**Conceptualization.** Conceptualization is considered to be one of the most critical activities in ontology design. In fact, the quality of a codified ontology depends on the quality of its underlying conceptual model (Guizzardi, Halpin, Guizzardi & Halpin, 2008). From a pragmatist view of semantics, conceptualization reflects human interests and purposes. In other words, a given domain of interest can be described and classified differently according to different purposes (Hjorland, 2007). 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 account end-user factors and was constructed as a system of meaning that includes how this domain content is interpreted and used by teachers and what types of tasks the ontology tool needs to support.

The subject domain of cultural heritage in general has scarcely been explored in ontology research. Modeling a domain of history, and 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, and 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, GO for bioinformatics, and EngMath for engineering). Also, if compared with hard 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.

As is often stressed in the literature, 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. 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 influenced the modeling choices made that capture common and shared meaning of the domain of interest. The outcome of the conceptualization activity was a prototype model of the TBS ontology. The model has been visualized through concept maps that provide a clear and intuitive technique for displaying knowledge models. The concept models were developed using Cmap Tools software. The list of terms collected during the knowledge organization 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 had emerged from the interviews with teachers and served as a framework to aggregate the terms and organize the concepts to develop the conceptual structure of the ontology. As it turned out, these upper-level categories tied in nicely with some of the thematic strands from the National Council for the Social Studies (NCSS) Curriculum standards for social studies (1994) and have been associated with the appropriate clusters of concepts on the concept maps (Figures 1–4):

- **Time** relates to NCSS II. Time, continuity, and change and NCSS VI. Power, authority, and governance.
- **Domain concepts** relate to NCSS VII. Production, distribution, and consumption and NCSS VIII. Science, technology, and consumption.
- **People** relates to NCSS IV. Individual, groups, and institutions.
- **Space** relates to NCSS III. People, place, and environments.

**Time.** Temporal dimensions are notoriously challenging to model, and temporal reasoning is still largely an open issue. Considerable research in artificial intelligence and computational linguistics has been focused on the use of linguistic means to represent and situate events in time. A stream of research has also taken place in the semantic Web community that focuses on various projects, including the OWL-Time ontology, intended to express the temporal content of Web sites and the temporal properties of Web services. 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). Temporal and spatial annotations enable contextualization of content, which 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 collection, where images are a considerable part of the content, temporal annotation would provide an essential means for enhanced retrieval. 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 and tasks revealed by the teachers suggested that the temporal dimension can be effectively represented through core
temporal entities that include “historical period” and “date.” “Historical periods,” 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,”12 which pertains to both 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. In addition, finding materials that enable teachers to compare and contrast primary sources through time and space was seen as highly desirable for classroom use. To this end, a set of relations has been identified that may facilitate these tasks. These relations express initiation and termination (begin/end) to specify time intervals, concurrence (during), simultaneity or punctual coincidence (when), and sequence (before/after). The concept model of this category is illustrated in Figure 1.

**Domain Concepts.** Domain-specific concepts were derived primarily from the subject matter of the TBS learning objects. The collection illustrates various aspects of living conditions of home-based 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, families of concepts were identified, including domestic life, labor status, family budget, home conditions, etc. These aspects were aligned to the extent possible with themes that addressed similar perspectives (e.g., farm life, home life, medical care, etc.)
from the National Council for the Social Studies (1994). They were displayed on concept maps as a visual device to help the teachers identify familiar instructional themes. The North Carolina Standard Course of Study also contributed discipline knowledge, from which additional concepts were derived 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 useful suggestions in the development of the ontology (i.e., Education: “How long students would go to school back then?”).

As is often the case, 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 modeled and it was also a challenge in terms of definition. In fact, the notion of poverty is prone to changes. For example, in the 1930’s 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 unusual resources for food, housing and shelter” (Oster, 1976, p. 6). Moreover, the federal government did not develop the definitions for the poverty thresholds until 1963–1964. In the context of this study, a definition of “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 Figure 2a and 2b.

People. As noted earlier, “people” was identified as a central category for the teaching of history. The relevance of this category was referenced 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 10 thematic strands identified by the NCSS to guide social studies instruction. Specifically, the 4th NCSS Thematic Strand, entitled Individual, Groups, and Institution, stresses the importance of 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.

Space. The use of ontologies for geospatial applications is a rather new research topic within the ontology research community (Kauppinen, Vaatainen, & Hyvonen, 2008). 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 more controversial issues being discussed (Casati & Varzi, 1994). 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. Teachers were concerned with the lack of geographic precision when accessing resources via named places. They also highlighted the need to contextualize and compare/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.). These types of entities refer to places defined by administrative boundaries and conditions that would be defined as flat 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). As suggested by several participants in the user study, the specification of areas at both county and state levels are essential in their teaching practices. The teachers described that 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 and geographical places change over time and can be known by different names. The TGN is the reference tool used for this portion of the ontology and served as a 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), but they are also problematic because of the variety...
FIG. 2a. Concept map representing domain concepts.

FIG. 2b. Concept map representing the category of “domain concepts”.
FIG. 3. Concept map representing the category of “people”.

of different types that exist and the relative implications for dependency (Winston, Chaffin, & Herrmann, 1987; Keet, 2006). For 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”; they enable aggregation by composition and hold transitivity. As Keet 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 that represent important tasks for teachers to perform. It is also 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 that can 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 Figure 4.

Results

The outcome of phase 2 was an ontology model prototype informed by the outcomes of the interviews and developed in the form of five concept maps (see Figures 1–4). The size of the TBS collection, which comprised approximately 150 primary sources, was well-suited to be the main source of domain knowledge because the acquisition of knowledge could be carried out relatively easily. As one of the tools that strongly influence history instruction, teaching standards were incorporated in the ontology design. In particular, the North Carolina Standard Course of Study proved to be an important source of the teachers’ search terminology and was therefore invaluable for developing a domain ontology for specific grade level history instruction.
FIG. 4. Concept map representing the category of “space”.

Phase 3: Evaluation of the Ontology Prototype Model

At this stage of development process, the TBS ontology had reached the form of a conceptual model, largely un-refined, that would serve as a prototype for assessment. As part of the conceptualization phase, a sub-activity was added that consisted of the evaluation of the TBS ontology model with a representative sample of end users. The rationale for introducing this additional step was to verify the appropriateness and potential usefulness of the model in preparation for its consolidation before proceeding with formalization.

Methodology

The evaluation of ontology models is not common in ontology engineering and the lack of an established methodology represents an open research issue. Ontology evaluation is
typically concerned with the evaluation of the formal quality of the ontology and aims to measure the technical efficiency of the ontology and, ultimately, its system implementation. Thus, evaluation is usually performed after the ontology has been formalized. On the other hand, conceptual modeling evaluation has a relevant place in software engineering, where 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). However, the literature points out the lack of a clear set of methodologies to support the practice of evaluating concept models (Moody, 2005; Brewster, Alani, Dasmahapatra, & Wilks, 2004). To date, conceptual modeling is still crafted and assessed in a relatively ad hoc fashion, relying largely on subjective views and common sense.

The evaluation performed in this study is more aligned with the idea of assessing the utility and usability of the ontology as a practice for “judging the ontology content from the user’s point of view” as described by Gomez-Perez, Fernandez-Lopez, and Corcho (2004, p. 179). This approach—qualitative in nature and user-centered—aims at assessing the adequacy of the ontology for its intended tasks and how well it represents the domain of interest.

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 that 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. 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 digital resources 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 assessing user acceptance of computers. 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. The TBS ontology model was evaluated by conducting a task-based user study. The study took place in the participants’ workplaces and in the usability lab of UNC’s Davis Library. For each session the participant was asked to complete a brief demographic questionnaire and to complete three tasks. The first two tasks required the participants to search for digital primary sources using Google and the TBS collection. The searches were screen recorded. The third task required 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. Protocol 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.

Participants

A pool of 14 social studies teachers from middle schools and high schools in Chapel Hill, North Carolina and the surrounding area participated in the study. As with most qualitative studies, sampling was purposive (Hamilton & Bowers, 2006). The sample was chosen based on appropriateness to the research purpose (6th-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 effect was pivotal in increasing the number of participants.

Interviews and tests took place during a 3-week period with 14 individual sessions that lasted 60–90 minutes each. The study participants were aged 25 to 50+ years. The majority of participants were female. Sixty-four percent of the participants held a master’s degree in education. Their teaching experience spanned from 1 to 30 years with a mean of 6 years.
In addition to demographic information, the study participants answered several questions regarding their experience with computers, the Internet, and 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 (57%). About half of the student population had 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.

Procedures

Task 1. Task 1 comprised 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 1 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:

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.

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 to determine whether they (a) found the search easy, (b) had any problems thinking of suitable query terms, (c) felt they had all the information needed to perform the search, and (d) took a particular approach to the search and, if so, why.

Task 2. For this task, the TBS collection 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. Participants were then given a few minutes to explore the Web site 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 1 interviews and based on the North Carolina Standard Course of Study—Social Studies—United States History, adopted in North Carolina schools:

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 question 3 first; the other half saw question 4 first 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. Participants were asked to continue searching until they were satisfied with the results but without exceeding a 10-minute time limit. The second time a faceted interface on paper was presented to the participants (see the Appendix). 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 that they might have encountered and used before. Participants were asked to consult the interface on paper and then reformulate the queries they 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 and concepts through the paper-based facets had influenced the search process. The interviews were audio taped.

Task 3. For Task 3, the participants were asked to manually navigate and annotate paper-based concept maps that represented 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 format of five concept maps corresponding to the upper-level categories of time, domain concepts, people, and space (see Figures 1–4). 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?" 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 walkthroughs 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. The entire session was audio taped.

Findings

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 5 and 10 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 with the content words in the original questions. Each search term was categorized by the degree of match with terms in the ontology model and in the original question using the categories defined in Table 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).

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 2 presents a complete list of search terms and phrases used for both questions, along with the number of times they were used.

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 to participants’ search strategies, revealing that the search terms were heavily dependent on the words and phrases in the question. The first question contained seven content words or phrases. Of the 13 user terms that were considered within the scope of the topic, 12 were from the question as either an exact match or a variant. The second question contained seven content words or phrases. 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,
<table>
<thead>
<tr>
<th>Categories of matching</th>
<th>Question 1</th>
<th>Question 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Terms/phrases (number of occurrences)</td>
</tr>
<tr>
<td>Same as ontology only</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Same as question only</td>
<td>3</td>
<td>1930s (13) Day-to-day life (1) Impact (1)</td>
</tr>
<tr>
<td>Same as both ontology and question</td>
<td>3</td>
<td>Great Depression (36) Virginia (41) Family (8)</td>
</tr>
<tr>
<td>Same as ontology Variant from question</td>
<td>1</td>
<td>Income (5)</td>
</tr>
<tr>
<td>Same as question Variant from ontology</td>
<td>1</td>
<td>Low-income (6)</td>
</tr>
<tr>
<td>Variant from ontology only</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Variant from question only</td>
<td>2</td>
<td>Life (2) Family life (5)</td>
</tr>
<tr>
<td>Variant from ontology Variant from question</td>
<td>2</td>
<td>Depression (1) Families (7)</td>
</tr>
<tr>
<td>Candidate for ontology inclusion</td>
<td>1</td>
<td>Rural (1)</td>
</tr>
<tr>
<td>Out of scope</td>
<td>9</td>
<td>Diary (1) Firsthand account (1) Photography (1) Photograph (2) Photograph (2) Primary resources (2) Primary sources (6) Richmond Newspaper (1) Sources (1) Waltons (1)</td>
</tr>
</tbody>
</table>

Total 22 14

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 earlier.

Qualitative data were also collected during the debriefing, which 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. Searches to both questions did not produce results they considered appropriate to satisfy the task’s scenarios. 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.”

Task 2 yielded teachers’ queries used to find relevant materials in the TBS collection, first by using the existing interface alone and then consulting the paper-based facets and terms. The objective of Task 2 was to gather evidence to assess the perceived usefulness of the ontology and 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 facets from both search sessions were collected and analyzed. As before, users’ search terms were compared with the ontology and to the original questions. A summary of results from each session is shown in Tables 3 and 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 five content words or phrases. Users derived 13 search terms from the question between exact matches and variants before the use of the facets. The postfacet search revealed a slight decrease in the use of question terms (seven 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 four content words or phrases. Although eight user terms were derived from the question text (three exact matches and five variants), in the postfacet search only one exact match and three variant terms were derived from the question, but 16 exact matches and five 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, two exact matches from the facets were used in the prefacet search for their second question, question 3. Similarly, teachers who saw question 3 first used one exact match from the facets and eight variants from the facets in the prefacet search for question 4.

Data from the session’s debriefing were analyzed to understand whether 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 participants found the facets useful. Several participants pointed out that the facets helped them with query formulation. Participants observed that the facets suggested terms they would not have thought about on their own, and several of them valued the fact that the facets offered them an overview of the collection, which enabled them to make more focused choices. One participant commented that it helped him to make informed decisions, which was useful for his class planning. Several participants also highlighted the usefulness of the facets for narrowing down their search options, thus avoiding the need to browse the entire collection. One participant pointed out the value of the facets for large collections of digital primary sources. 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: “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.” Teachers’ reactions to
being able to use an implemented version of the paper-based faceted interface were, in general, very positive. 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.”

Task 3 data were used to (a) 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 by 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. The analysis of the drawings and annotations revealed that participants’ pathways varied as to a starting point and direction, but they focused on similar clusters of concepts. For both questions, the majority of participants started by targeting the time period and then proceeded towards the geospatial concepts reaching their preferred level of specificity. Four participants adopted a reverse strategy and started from the geospatial area. Three participants chose the category of person as a starting point, but then performed the actual drawing by 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 5).

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.

The protocol analysis that accompanied the navigation and annotation of the concept maps was particularly rich and revealing. Because of the familiarity that most of the participants had with the use of concept maps as an educational tool, the flow of thinking and the concurrent verbalization was 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

FIG. 5. Teachers’ annotated concept map for “day-to-day” for question 1.
the study. Additionally, the debriefing interviews included questions intended to solicit feedback on the clarity of the concept maps and their completeness and correctness from the perspective of 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.

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 recognized by participants as the way they typically identify time periods in their teaching and learning activities. For further development of the ontology model, participants 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 that represented 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,” which was chosen as a target concept by eight participants, confirming what had emerged from the phase 1 interviews; “county” was definitely the lowest level of specificity that teacher participants considered useful in the context of their searches. 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. Regional areas that include the Mountains, the Piedmont, and the Coastal Plain, defined in the TBS ontology as subregions of North Carolina, appeared to be useful for addressing comparisons. Also, two participants were looking for Eastern Carolina: “Everything east that I know grows a lot of tobacco”; “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. I found it interesting that 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). Indeed, the concept map would lead to the “neighboring state” through the relation of “adjacency.” The participant’s comment served to validate the usefulness of this relation.

Coverage and Modeling Issues

All participants commented in positive terms on the domain coverage offered by the concept maps. 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 but he would also look for challenges from the Supreme Court, so adding terminology such as the judicial or “third branch” might be necessary.

From the analysis of maps’ annotations, participants added a few concepts 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 that 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). These suggestions seemed to express the need for a “cause-effect” type of relationship, which the TBS ontology had not included, and highlighted 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 involves the risk of producing connections that are simplistic at best, subjective or biased at worst. Another interesting modeling issue with both conceptual and terminological implications is related to the notion of minority groups addressed in 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. 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 7).

One participant recognized the ambiguity that the concept “minority” may carry when suggesting to add the concept “Hispanic.” He was puzzled if he should consider it a race or ethnicity: “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 about the implications of using the concept “minority.” She made the point that “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.”

**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 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 and, overall, they liked the terminology used.

**Usefulness**

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 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 socioeconomic class to a lower. You can tweak your lesson to have students understand how they...
FIG. 7. Teachers’ annotated concept map for “minority groups” for question 4.

differ.” Several participants recognized and appreciated the opportunities the concept maps provided to interrelate concepts in ways that were useful for their 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.” The potential usefulness of the ontology as an educational tool was also noted: “It gives you a lot of ideas about where you could go. You could create almost two weeks worth of lessons off these maps.” Also interesting was the way the maps were viewed by two participants in particular. 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). The findings from this phase 3 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 strategy 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 prototype model.

**Discussion of Results**

Both 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?—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 inspiring ideas for learning activities. Overall, the study findings were encouraging about the potential the TBS ontology holds to help social studies teachers find primary sources.

The nature of the domain of history, which is largely interpretative and less structured and specialized like the medical or legal domains, posed a major challenge to the development of the ontology. The lack of existing ontologies specific to the domain of the TBS collection to serve 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 with the introduction of two additional activities. 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. Understanding teachers’ context was key for gaining insight on how the ontology should be designed 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 their 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.

The second methodological addition was the evaluation of the ontology, introduced at the stage of model prototyping. Although the use of conceptual models to elicit user feedback and evaluation is a rather common practice in software development (Beyer & Holtzblatt, 1998), it is not part of the current ontology engineering practice. The rationale for adding this step to the building process was the assumption that a sound ontology model is the basis of an effective ontology implementation. More important, 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 and 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, then they may suggest a major reconsideration of the purpose or scope of the ontology or, more drastically, even an end to the project. Expanding the methodology 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 and receive suggestions on how to further improve it, as discussed next. Both steps contributed to streamline the process in that it is much easier and less expensive to make changes in the early stages of development than to modify it once formalized and implemented. As discussed, 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 the ontology engineering process for the richness and relevance of the background knowledge collected. One reason for the effectiveness of the interviews’ outcome may be because 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.

Evaluation of ontology models is not a common practice in knowledge engineering, and it is even more unusual when conducted from a user perspective. The main challenges of this phase of the study were related to study 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) or system performance. The aim of the study was instead to assess the quality of the ontology for consolidation before the transition to 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 1 interviews and derived from the North Carolina Course of Study. The data were collected using multiple techniques, including demographic questionnaires, search and annotation tasks, post-task interviews, think-aloud protocol, 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
Although the large majority considered themselves com-
helpful to: (a) formulate and/or refine queries by suggesting
indeed aligned with the literature. The facets were considered
Kirkham (2004) suggest, would facilitate the seeking process.
lection and “form a mental map of the subject areas that are
coverage of the collection, facets help to learn about the col-
reduce the cognitive effort and the time required for inde-
Lee & Olson, 2005). This type of support may, for instance,
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protocols indicated that the level of specificity was aligned
overall to the search needs of the participants. This was partic-
ally perceived useful during the search process. The
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suggesting alternative query entries, and presenting new ideas
and directions (Bates, 1989; Ellis & Vasconcelos, 1999;
Lee & Olson, 2005). This type of support may, for instance,
reduce the cognitive effort and the time required for inde-
generally, for indexing systems tailored to history teaching
and learning at the grade level.

The second task asked participants to search the TBS col-
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
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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 sug-
gested by participants through annotations or verbal feedback
filled holes in the clusters of concepts I had intentionally
left incomplete (e.g., additional ethnic groups and the judi-
cial branch) to see if teachers would contribute suggested
concepts/terms. It was also interesting to see that the par-
ticipants targeted concepts, such as “one-room school,” that
were derived from teaching activities described in the inter-
views and initially added almost reluctantly to the ontology,
thus revealing 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 ques-
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and learning at the grade level.
Conclusion

This study examined the potential of a domain ontology to facilitate the search process and ultimately the use of a collection of primary source materials for classroom instruction. Under the assumption that a domain ontology that represents cultural heritage materials is more effective when it integrates the information requirements of end users into its design, the study tested a user-centered approach to the construction of an ontology for the TBS collection, a digital collection of primary sources part from the UNC-CH University Library.

Ontologies, like any model, represent specific aspects or views of a domain of interest. Tasks influence what and how knowledge is represented. The rationale behind having end users participate in the early stages of the development process ensures that the system is useful and meets the needs and expectations of the intended audience. Although this tenet may sound axiomatic, a user-centered approach is still rare within the context of digital library development and is even more rare in the field of ontology engineering. Typically, knowledge engineers in collaboration with domain experts construct ontologies. Involved representatives from the user community in the design cycle of the ontology remains an unconventional choice.

The three-phase study provided 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. 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 later found to be important elements in the design of the ontology 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 worldview offered by the ontology and the teachers, in large part because of 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 evaluation of the prototype model 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 primary sources, where few domain-specific ontologies are available for reuse and whose subject matter is largely unstructured and highly interpretative.

It must be acknowledged that there are limitations to the study. The homogeneity of the study participants, all coming from the same relatively small geographical area, prevents the generalization of the results. Social studies teachers from other parts of the country may have different information needs and views of the domain of interest. Moreover, the number of study participants was constrained by practical issues, such as the availability of interested teachers in the vicinity.

More work needs to be conducted on developing the TBS ontology for real-world application and further research is needed to evaluate how effective the TBS ontology is in the context of a working application. The results from this study encourage the continuation of the development process that can be done by refining and consolidating the prototype in light of teachers’ feedback received during the evaluation and proceeding towards the representation of an ontology 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. “Ontologies are agreements, made in a social context, to accomplish some objectives. It’s important to understand those objectives, and be guided by them” (Gruber, 2003). Aligned with this tenet, this study offers a notion of ontologies as the result of a pragmatic process in which a user perspective is built into the design cycle. Although the methodology needs to be further tested and formalized, this study suggests that the involvement and the contributions of user communities to ontology development represent important areas of research 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).

Endnotes

1http://www.lib.unc.edu/ncc/tbs/report.html
2http://www.lib.unc.edu/ncc/tbs/report.html
3http://www.getty.edu/research/conducting_research/vocabularies/tgn/
4This is an educational guide to the Great Depression sponsored by the Franklin and Eleanor Roosevelt Institute at http://newdeal.feri.org/
5http://www.learnnc.org/
6http://www.openclinical.org/prj_galen.html
7http://www.geneontology.org/
9Cmap Tools is a software product developed by the Institute for Human and Machine Cognition (IHMC) and is freely available for educational use (http://cmap.ihmc.us/).
10http://www.w3.org/TR/owl-time/
12"Events are types of entities which represent occurrences in space and time (car accident) historical event (space and time) (Perry, Sheth, & Arpinar, 2006, p. 7).

13"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).

14For example, the concept of “river” was included.

15http://www.getty.edu/research/conducting_research/vocabularies/gng/index.html

16Part-place cannot be separate from the whole-area (Odell, 1998).

17The 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)

18The 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).


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Pollack, B.H., & Society, 7(2), 93–104.


### Appendix

**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

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

**ECONOMY**
- Industry
  - -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
  - LIVING CONDITIONS
  - -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

**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