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, & Marlino, 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

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