

# Transparency and the future of semantic searching in academic libraries

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**Abstract.** “Semantic search” is a fairly broad term without a fixed goal amongst developers. Most agree that semantic searching should reach beyond simple keyword or text/string matching in order to provide more robust taxonomies and relevant information retrieval systems. Many novice users and first-year students struggle to retrieve the scholarly sources they desire because they lack the specialized vocabulary attained through advanced years of study. Most students are used to the dominant semantic search discovery system, Google and Google Scholar, but few students understand how these systems work. Query parsing, fuzzy matching, and understanding how semantic searching utilizes taxonomies for more accurate tagging is not usually a consideration for a desperate sophomore looking for last-minute sources to finish a paper that is due the next day. So, there is a danger that meeting a student’s perceived need for a Google-like discovery system is more important than creating a transparent system. However, information literacy and library instruction must give careful consideration to these issues and be able to help emerging scholars/students understand both the ethical and practical horizons of semantic search tools.

Keywords: Semantic searching, ethics, library and information science, knowledge organization systems, semantic modeling

## 1. Introduction

Rolling out an effective semantic search discovery layer for a library knowledge organization system (KOS) has become the Holy Grail for some of the dominant library vendors currently serving academic libraries. EBSCO, Encore, Primo, Summon, and others are acutely aware that their search engines have to compete for the attention of their users with Goliaths in the field, such as Google. Academic librarians often face the challenge of teaching students and researchers the virtues and nuances of using their university KOS. However, without a semantic search layer, many students struggle to find relevant sources that require a very controlled vocabulary. The convenience of Google and Google Scholar all too often wins out for many novice researchers. Simply put, Google readily supplies meaningful connections between keywords (semantics) through predictive text that library discovery systems lack. While there are numerous problems with students’ reliance on Google, the main issue often comes back to the fact that Google is a black box algorithm. Library discovery systems, on the other hand, should be built around transparency. Catalogers need to understand how the meta-data (Resources Description and Access (RDA) and MARC records) they create is being used by the discovery service, and reference/instruction librarians need to be able to articulate that process to end-users for more effective information retrieval. Currently, vendors such as EBSCO are in the development phase of their own semantic search discovery layer to try and bridge the gap between the convenience of Google and the validity of library discovery services. While some librarians may rush to adopt the latest semantic search service provided by their preferred

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vendor in an effort to satisfy the perceived needs of their users, prudent Library and Information Science (LIS) professionals should consider some practical and ethical issues being raised by their scholarly peers.

A KOS with semantic search capabilities is complex, often beyond the scope of understanding for some library practitioners. The knowledge gap between how their current KOS works and what is taking place when the added semantic search layer is applied can leave some relying on the goodwill of vendors. It is, however, imperative that librarians not fall prey to the same ambivalence as their students and sacrifice transparency for convenience. Librarians should lean into the complexity and educate themselves on the practical and ethical issues involved in semantic search services if they are going to be co-creators with vendors in this new semantic frontier.

## **2. A review of the literature and ways to move forward**

The work of Silva, Reis, Fernandes, and Pereira [1] lays out the practical considerations for information-science-based semantic modeling, while Zhitomirsky-Geffet's [2] research projects an ethical horizon for a socially-just KOS. Silva and fellow researchers [1] cut to the heart of the issue with their observation that leaps in computer algorithms are the driving factors for advances in search tools, which has prioritized the computer-science perspective over that of information science. In an effort to balance the scales between computer-science and information-science-informed semantic modeling, the authors employed a deductive design that was empirically validated in two separate ways. Their approach was a "multi-leveled framework for semantic modeling (MFSM) [1, p. 502]". MFSM is based on a pragmatic information-science theory with an "interpretive epistemological process [1, p. 511]". Ultimately, their goal was to overcome the low levels of abstraction found in traditional models and to find ways to move beyond searching for resources by using basic referential terms.

MFSM takes place on four levels (objects, classes of entities, instances, and domains) with four propositions (process of classification, decomposition, instantiation, and, most importantly, contextualization) for signification (the process of making meaning between signs or symbols) that support each level. Their first step was to match an object/document with at least one, but preferably more, classes of entities. This is the lowest level of modeling and would include categories such as periodicals, DVDs, or archival objects. The second step is to identify as many attributes as possible; for an article it would be things such as author, year, or editor. By the third level, MFSM starts to become more advanced. They state, "An object mapped through classes of entities and characterized by attributes is individualized through a data instance, called and instantiation process [1, p. 506]". This allows for domains to position an object or text within a semantic context by showing its signification to other texts or objects. Finally, they propose that any text or document can be associated with one or many other domains (objects or texts) through the contextualization process.

The authors suggest that modeling takes a hierarchical approach where levels one and two become more fixed in a parent-child computer model. This allows for levels three and four to enable the fluidity of natural language and be contextualized by knowledgeable LIS gatekeepers. Ultimately, the real advantage of MFSM is that it allows for different levels of creation. Experts in computer science and information science build the basic framework with fixed fields, leaving local catalogers and reference/instruction librarians to begin building the contextualization between domains (semantic search). Like all semantic search strategies, the process begins slowly with few connections. However, as more connections are made with a shared community of LIS professionals, the semantic web grows and becomes more individualized and meaningful as more usage and contextualized data is added. Overall, Silva, Reis, Fernandes, and

Pereira's [1] real contribution is building a schematic for computer-scientist and LIS professionals to work together to create a platform that benefits users, remains transparent, and is capable of the linguistic fluidity needed to change with time.

While Silva and colleagues [1] provide a working framework for semantic search, they do not venture far into the ethical dimensions of such a system. Zhitomirsky-Geffet [2] offers some workable solutions for addressing some major ethical concerns that LIS professionals might have with semantic search models. The most important element in Zhitomirsky-Geffet's model is the insistence on diversifying the KOS by allowing LIS communities to assign validity scope types to form logically coherent subsystems. Their research relies on Galili's Cultural Content Representation [3], which basically states that all scientific knowledge consists of the main body of content and then periphery information relevant to smaller communities. Ultimately, the approach conforms with the Open Knowledge Network, which is ontology-based and allows for the subsystems to become interlinked to become, with time and use an extended semantic web. This allows for marginalized communities and individuals to contribute and co-exist with dominant theories by allowing domain knowledge to be part of the ontological statements "in the form of a triple: concept – relationship – concept [2, p. 1129]". Their triadic structure allows for opposing views to co-exist between theories, which keeps marginalized voices from being drowned out by the most popular viewpoints. Co-creation of this type allows the record to be linguistically diverse and potentially more inclusive by means of greater diversity through broad in-puts.

Aghaei and fellow researchers [4] uncover the history of search and discovery tools used from the early days of the World Wide Web to the present. Their research found that the explosive growth of data has resulted in the need for radical changes in the way users find information. The early days of searching were reliant on keyword matching, which has been overtaken by semantic search (drawing meaning from the relations between objects/symbols), natural language query parsing with sophisticated rankings, and simulated human question-answers being supplied by Machine Learning. The resulting article provides a helpful history of searching and search tools, as well as providing a very helpful example section that gives practical explanations for complex topics in information retrieval systems. Librarians will find this article helpful for understanding how these advances in search tools will impact their knowledge organization system (KOS).

Ananny and Ziewitz [5] examine the new demands that will be placed on ethics with new breakthroughs in increasingly-powerful algorithms. In this way, they assume a non-neutrality position and uncover the power behind all networked information algorithms (NIAs). The authors use a pragmatic approach that is empirically grounded to uncover how algorithms benefit their constituents. The authors break groups into "publics", which are the associations of people groups being sorted by algorithms. The creation of these publics creates marginality with insider versus outsider grouping. The authors then examine the probability of an algorithm creating marginalization by means of similarity to past algorithmic instances. Overall, the researchers take an approach that directly flies in the face of companies such as Google, who think it is enough to "not be evil". Instead, they take the proactive position that ethics is the study of what "ought we do".

Similarly, Beghtol [6] describes ethical decision-making methods for creating, revising, and maintaining knowledge representation and organization systems, particularly in relation to the global use of these systems. The analysis uses a three-level model and the literature on ethically-based decision-making in the social and technical sciences. In addition, methods for making these kinds of decisions in an ethical manner are presented. This multidisciplinary approach is generalizable to other information areas and is useful for encouraging the development of ethics policies for knowledge representation and organization systems and for other kinds of systems or institutions. Beghtol [6] stresses that new technologies have led

to an explosion of globalized information sources and services for gaining access to that information. Her aim is to create globalized and ethical knowledge organizational systems that protect cultural information diversity. Her basis is the United Nations policy on the Declaration of Human Rights and its thirty articles on “peace, dignity, and equality on a healthy planet [7]”. In particular, Beghtol looks at the concept of hospitality that upholds the rights of individuals and their right to represent themselves culturally. Hospitality stresses the importance of diversity in the creation of a KOS and the need for marginalized cultures to contextualize their perspectives. She states, “Despite the complicated networks of relationships among individuals and their individually chosen complex of cultures, the concept of cultural hospitality with user choice options appears to make it theoretically possible for people to think globally, to act globally, and, at the same time, to think and act locally and individually [6, p. 532]”.

Bencsik, Szabo, and Juhasz [8] look specifically at marginalized communities and investigate the ethics of a majority population operating in a minority subculture. The implications for their research and findings speak to ethical KOS development when created by majority representatives. Their research investigates ways that minority groups investigate whether a system created by the majority is trustworthy. The authors define trust according to the “leader-member exchange theory”, which evaluates the flow of information between the majority and minority. Equality in the exchange of information leads to greater levels of trust and creates a more ethical exchange of knowledge. Mistrust by a minority population in a KOS signals the probability of an unethical system. While the researchers were primarily concerned with economic and sociological issues of trust/mistrust/ethics in Hungary, their research opens up important conversations for information professionals regarding the ethics and power structures inherent in KOS. Of particular interest is the idea of trust and mistrust being a signal for unethical designs in search tools when considered from the viewpoint of a marginal community.

Cifariello and colleagues [9] developed a semantic search tool called “Wiser”, specifically intended for academic libraries that utilize a wiki-style knowledge graph by means of entity linking. Wiser relies on profiling the author and their expertise by drawing from a weighted Wikipedia entry. In short, when a user enters a query, the algorithm pulls from both classic keyword retrieval and the semantic relatedness of the author’s areas of research. The authors claim that their semantic search meets the needs of users better than other systems. The Semantic web is built as profiles are created on authors and the explicit knowledge realms they operate within.

Cojocarú [10] looks at the ways pragmatism can serve as a basis for constructing moral solutions to practical problems. Cojocarú utilizes the work of Charles Sanders Peirce [11] to distinguish between practical and theoretical ethics. This makes it possible for the author to focus on moral pragmatics for moral decision-making rather than moral philosophy proper. Such a stance allows practitioners/professionals in their respective fields to make decisions rather than relying heavily on the work of moral philosophers. By relying on “Critical Common-sensism and individual conscience”, the author relies on the individual to be constantly improving their morality (i.e., right action) in a good-faith effort to constantly be evolving for the better. Cojocarú’s moral pragmatism calls for constant experimentation when assessing the rightness of an action or decision. If such a moral experiment leads to greater human flourishing, it is seen as successful. However, moral pragmatism calls for constant revisions and change with time. While Eaton [12] examines the many ethical concerns that crop up when building and using technologies in the library. He breaks up technology into two categories: pervious and impervious. Pervious technologies are those that can be altered to suit the ethical needs of library professionals, while impervious technologies cannot be altered in any significant way. Eaton uses the library tool Open Journal Matcher [13] as a case study to discuss how to evaluate a technology for its pervious and impervious characteristics. Ultimately, his concern is to show how pervious systems that have been combined with diverse perspectives yield the

most ethical systems. As such, the author suggests library professionals begin using and building more pervious technologies and diversify that technology by getting a broader range of inputs, especially from marginalized groups.

Hadi [14] investigates how culture forms the basic framework of ethics and impacts the biases found in library KOS. In particular, classification and indexing language is examined by looking at the ways cultural and racial biases impact knowledge organization. Hadi breaks down ethics into two dimensions. The first ethical dimension for LIS professionals to consider is the impact of information and communication technologies (ICT) on the life-cycle of information sources (e.g., information poverty, privacy, access, property rights, etc.). The second dimension is the connections between KO and culture and linguistics. Cultural specificity plays a huge role in standardized classification, which can present ethical issues when the dominant culture assumes its beliefs, morals, and politics to be normative for all. In an effort to understand bias and work toward a more inclusive KOS, the author suggests incorporating Adler and Tennis Taxonomy of Harm [15]. While universal standards of ethics do not exist for knowledge organizers, awareness of implicit cultural bias is a good first step in building more diverse ICTs.

Formica and fellow researchers [16] look to enhance semantic search tools with rating scores, allowing semantic similarities to be weighted. The more frequently a semantic similarity is used, the greater the ontological “weight” assigned. The author uses a simple rating scheme of high, medium, and low and makes the case that weighting semantic searches with scores gives users greater input into the creation of semantic webs. In theory, the system should become more diverse through user interactions. SemSim (semantic similarity) relies on both the preferences of the users and the quality of resources. Garigliotti, Hasibi, and Balog [17] note that Entity types are usually hierarchically assigned to the system’s taxonomies. The authors explore ways in which entity types can be better used for entity retrieval. Entities include things such as publishers, places, authors, or associated individuals, and provide some of the most basic and widely searched questions. Ultimately, the authors are concerned with ways that term-based information can be paired with type-based information, their model presents a way forward. Hemam, Djezzar, and Djouad [18] consider ways that KOS professionals can build in multiple viewpoint ontologies for more equitable systems. Ontologies are based on similarities between domains of interest. The authors use description logic to overcome discrepancies between different communities who view domains in opposing ways. Equitable KOSs are able to incorporate different viewpoints for the same domain by building multi-viewpoint ontologies. The authors recommend “stamping” data concepts, instances, and attributes with multiple viewpoints and make that data pliable for future changes. Four aspects of stamping include using specialized domain knowledge, incorporating multiple viewpoints, establishing domain experts, and scoping the ontologies with the most relevant global terms. The authors suggest that linking multiple viewpoints can act as bridge between domains and diversify a KOS.

Building a proper thesaurus also plays a critical role in forming an ethical basic for semantic search. Martinez-Gonzalez and Alvite-Diez [19] discuss the role of thesauri in building a semantic web. Thesauri follow a prescribed set of rules for maintaining integrity, which is often set by the International Standards Organization (ISO) [20]. Over the years, thesauri have been moving toward concept-based connections rather than term-based. This shift in thesauri theory has been impacted by the semantic web and impacts the semantic web. While there has often been a focus on the more complex aspects of semantic search technology, the authors remind readers of the important role that thesauri play in the creation of semantic tools. They further discuss the important role that thesauri rules play in making meaningful connections in semantic searches while also emphasizing the important role that time and change play in creating an adaptable system. Noruzi [21] take the conversation further and makes a case for building a “folks thesaurus” that incorporates the natural language linguistics found in hashtags, wikis, social tagging, and



user search queries to build better semantic connections between domains. The goal is to begin to better bridge the gap between the controlled vocabularies of scholars and the users who are actually doing the searches. The author suggests that a folk's thesaurus, by its very nature, needs to be built from the bottom up and prioritize the natural language of user queries to build semantic connections. A folk's thesaurus is constantly changing and prioritizing new connections, and users continue to input new search queries with cultural modifications. Ultimately, a folk's thesaurus combines wiki software with knowledge organization systems.

Two meta-studies pertaining to ethics and algorithms come from Floridi and his team of researchers. First, researchers (Mittelstadt, Allo, P., Taddeo, M., Wachter, S., & Floridi, L., 2016) [22] map out the current debates and issues in ethics and algorithms, creating a meta-analysis of the road thus far and offering productive avenues to move forward. At this point in the history of algorithms, it should go without saying that algorithms are inherently value-laden. However, this fact is often overlooked by the general population. Evaluating the ethical impact of an algorithm often proves difficult, according to these researchers. It requires time and a multi-level approach for evaluation. There is often a gap of complexity that separates the creation of an algorithm and the subsequent impact on different populations of people. In an effort to evaluate algorithms, the authors suggest incorporating three levels of concerns: epistemic, normative, and traceability/transparency. As algorithms increasingly mediate life for many individuals, the authors explore the important ways that ethics need to be injected into their creation and evaluation. Mapping these issues concerning the ethics of algorithms is the first phase in creating more equitable ICTs. Secondly, a team of researchers (Tsamados, Aggarwal, N., Cows, J., Morley, J., Roberts, H., Taddeo, M., & Floridi, L., 2021) [23] address emerging problems and LIS-based solutions. Their research focuses more sharply on Machine-Learning-derived algorithms and addresses epistemic and normative issues. Research on ethics and algorithms has greatly increased since the author's first article in 2016. Artificial Intelligence-generated algorithms have grown exponentially, as has the ethical concern for their impact on users. Furthermore, the term algorithm has been applied much more loosely in recent years, and complicated conversations on the topic. While mapping the wide horizon of algorithms, the researchers focus on the topic of transparency. The lack of transparency in some algorithms kills the possibility of dialogue and ethical change with those operating outside the organization that created the technology. Therefore, it is suggested that creators emphasize transparency when creating algorithms, and users (especially LIS professionals) educate themselves on how those systems work and where ethical issues may arise.

Ridi [24] distinguishes between technical/practical operations and ethical goals and how those two domains do not naturally work together for the same purpose. He explores the transversal nature of KOS construction and the ethical dimensions of each layer. A critical piece of Ridi's research is his insistence that LIS professionals should not abandon their ethical standards out of convenience for incorporating the latest technology. While there is not a universal standard for ethical norms and ICTs, Ridi suggests that three values emerge as meta-norms: intellectual freedom, professional competence and neutrality, and social responsibility.

Two important conferences took place to discuss ethic and information organization. Smiraglia [25] reported that the finding of two conferences discussing ethics and information organization that took place in 2009 and 2013. The main thrust of the conferences was to take ethics out from the backburner and make it a dominant topic in knowledge organization. Essentially, the author is arguing that LIS professionals take their seats at the table with software developers to create more ethical KOSs. Smiraglia makes the argument that humanist epistemologies should appear alongside empiricist and rationalist epistemologies in knowledge organization.

Stahl [26] offers the opinion that critical research is inherently ethical and, therefore, influences information systems of which they are a part. Stahl draws from the German and French schools to establish norms for critical research. Most notable is the author's suggestion that critical research's most important characteristic is the author's intention to promote social change. Sources with critical intention alter the semantic meaning and domain connections within a KOS. Stahl's work suggests that critical LIS theorists become more conversant with developers in an effort to build ethics into KOSs for a more equitable future.

Waller [27] argues that ICTs using semantic search alter what users know and impact how information is understood. The subtle influences of semantic search often go unnoticed by users as they have become such a "natural" part of their daily lives. As semantic search tools impact what becomes "legitimate knowledge" for user groups, LIS professionals have to deepen their understanding of these tools in order to inform users how these tools aren't as objective and authoritative as they appear. Waller further maps out the elements that are constructing the semantic web and interrogates them and their level of transparency, evaluating them on the diversity of their ontologies and classifications in an effort to make those "invisible" things visible.

Finally, Zhitomirsky-Geffet and Hajibayova [28] present a framework for creating ethical KOS by prioritizing multiple perspectives. They argue that transparency requires that LIS professionals leave behind the ideal of neutrality and embrace the fact that knowledge organization is inherently laden with a particular perspective. By embracing and acknowledging implicit bias, the authors hope to encourage a platform for multiple viewpoints to appear alongside each other. They push for an "ethics of care", which opposes domination by any one perspective and pushes for a dialogical position. In short, the authors argue that an ethical KOS is only possible with transparency and diverse representation.

### **3. Conclusion**

In the race to offer a working semantic search discovery layer it is important that library vendors work closely with librarians during the development process to avoid creating a black box algorithm. While there are bound to be proprietary issues concerning the development process, it is essential that librarians be able to understand and articulate more than the simple input and output characteristics of a discovery system. Semantic search has far-reaching implications for both information storage/creation and retrieval. Catalogers have to understand how semantic search will impact and interact with the meta-data they create and how more complex relevancy rankings will draw upon it. On the other side, reference librarians and library instruction professionals must be able to explain the search process to students and faculty. Transparency is critical if vendors are going to provide semantic search capabilities in their discovery services that holistically benefit academic libraries.

The future of semantic search is still unclear for many library KOS, but there is a practical and ethical path forward. It will be up to LIS professionals to fight for their specific concerns when dealing with vendors and find ways to engage in the creation process. LIS professionals have a unique perspective and readily wrestle with ethical concerns often overlooked by computer-science professionals. Creating a diverse and democratic semantic future will take a great deal of dialogue and work on the part of both vendors and librarians, but the semantic frontier is ultimately about users and meeting their information needs in new, ethical, and informationally-fruitful ways.

If a mutually beneficial future is to exist between academic libraries and vendors in the new semantic frontier, it must distinguish itself from black box algorithms with a thoroughgoing commitment to transparency. Forging this new frontier will certainly take patience, dialogue, and compromise on both sides.

But the future is bright for semantic search discovery tools if vendors can keep the lines of communication open during the development process and not only for a cursory “show and tell”.

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