

Standards or Semantics for Curriculum Search?

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ABSTRACT

Aligning digital library resources with national and state educational standards to help K-12 teachers search for relevant curriculum is an important issue in the digital library community. Aligning standards from different states promises to help teachers in one state find appropriate materials created and cataloged elsewhere. Although such alignments provide a powerful means for crosswalking standards and curriculum across states, alignment matrices are intrinsically sparse. Hence, we hypothesize that such sparseness may cause significant numbers of false negatives when used for searching curriculum. Our preliminary results confirm the false negative hypothesis, demonstrate the usefulness of term-based techniques in addressing the false negative problem, and explore ways to combine term occurrence data with standards correlations.

Categories and Subject Descriptors

K.3.1 [Computer Uses in Education]

General Terms

Algorithms, Human Factors

Keywords

Educational Standards, Digital Library, Educational Resources

1. SPARSE STANDARDS ALIGNMENTS

Builders of digital libraries (DL) of K-12 curriculum realize that teachers want to quickly find learning objects of reliable quality which are relevant to assigned educational standards and appropriate for their context of teaching [2, 4]. Hence, aligning learning objects with educational standards and learning benchmarks is currently a key emphasis for the NSF National Science Digital Library (NSDL) project [3] (www.nsdll.org). Identifying standard-to-object and standard-to-standard mappings should help teachers search for curriculum that aligns with the standards to which they teach. Current standards alignment initiatives include:

- A joint project at JES&Co and the University of Washington.
- A project at Syracuse University's Center for Natural Language Processing (CNLP) [2].

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- Collections such as DLESE, TeachersDomain.org, and TeachEngineering.org that provide standards-based search.
- For-profit initiatives such as www.nettrekker.com, www.academicbenchmarks.com and www.statestandards.com.
- Ongoing collaborations between some of the above projects and organizations.

As results and products from these collaborations begin to emerge, it is important for the DL community to evaluate the early data and consider how alignments can be used to support curriculum search across multiple sets of standards. We submit that standard alignment matrices are inherently sparse. As a consequence, even high quality, vetted and calibrated alignments will result in a significant number of false negatives when used as a basis for searching standard-compliant curriculum.

Table 1 lists alignment results for K-12 science, technology, engineering and mathematics (STEM) standards in the states of Colorado, Oklahoma, North Carolina and Massachusetts. The data are derived from a manual alignment effort conducted as part of the TeachEngineering.org NSDL project. In this effort, state standards were aligned to several national standard frameworks — NSES, AAAS Benchmarks, ITEA, ISTE, McREL National and NCTM. For the four states involved, this resulted in 3386 alignments. State-to-state alignments were then determined using these intermediary alignments. Alignments were coded as weak, fair, or strong. Weak alignments were not used to compute the data for Table 1 which shows that, indeed, the state-to-state alignment matrix is sparse. On average, each of the 1948 K-12 STEM state standards aligns with only .4 standards in the other three states, with a low of .29 for Colorado and a high of .58 for North Carolina. Extrapolating these numbers to the national level, each state standard would have an average of $.4/3 \times 49 = 6.53$ alignments. Accordingly, we might have to conclude that searching for applicable curriculum based on standard alignment only might not yield many results.

Table 1. Sample of U.S. states with K-12 STEM standards and alignments in TeachEngineering

	States				Overall
	CO	MA	NC	OK	
Standards	117	691	415	725	1948
National Alignments	24	370	237	266	897
National Alignments/Standard	.21	.54	.57	.37	.46
State Alignments	34	235	240	266	775
State Alignments/Standard	.29	.34	.58	.37	.40
State Alignments /Standard (U.S.)	4.73	5.55	9.47	6.04	6.53

2. FINDING ALIGNED CURRICULUM

To explore the practical implications of alignment sparseness, consider a search related to the *Pythagorean Theorem*. In addition to simple word searching, TeachEngineering includes a standards-based search tool which leverages the previously described alignments. Users can select a standard and search for resources related either to that standard or to aligned standards in other states.

A standards-based search on Massachusetts standard MA/Math/Geometry-8.G.4: *Demonstrate understanding of the Pythagorean Theorem. Apply the theorem to the solution of problems*, returns no matches. But a word search on *Pythagorean Theorem* finds three relevant learning objects. Our standard alignment data suggest that MA/Math/Geometry-8.G.4 aligns with McREL/Math/Geometry 5.7 and 5.3, NC/Math/Geometry 3.2 and OK/Math/Geometry & Measurement 3.5. Although TeachEngineering uses this alignment information to search curriculum, it cannot find the three supporting learning objects because the authors aligned their curriculum with Colorado standards, yet these Colorado standards do not align well with MA/Math/Geometry-8.G.4 or any of its correlated standards. Given the sparseness of the alignment matrix, this is not surprising. Granularity variations across the standards—some standards being broadly defined whereas others are very detailed in nature—mean that a given document may well apply to one standard but not the other. For example, while the Massachusetts standard emphasizes the *Pythagorean Theorem*, other standards focus more generally on triangles, making them a poor match.

3. TERMS vs. ALIGNMENTS AND TERMS

The previous example illustrates that term-based semantics for standards-based search are important even when high quality standards mappings are available. To better understand the usefulness of standards alignment, we set out to test the notion that terms and standards alignments can be used together to improve standards-based search in TeachEngineering. We compared term-based search to search employing both standards alignments and terms in four different treatments. We tested the treatments using *AAAS benchmark 4.C.4 Grades 9-12* which covers the interaction of plates in the Earth's crust. To get a set of sample results, we ran a word search on *tectonic* and retrieved a list of 11 documents. *Tectonic* is a search term a teacher would be likely to try, but it does not appear in the standard.

We developed two initial versions of term-based search. The controlled vocabulary treatment (CV) indexes using only terms which are identified as vocabulary words or key words in a TeachEngineering learning object. The noun phrase treatment (NP) employs a longer list (1000+) of terms extracted from the text of the learning objects. In these treatments, a relevance score is computed between each term and each document or standard that includes the term. The computation considers term frequency and various forms of the term; e.g., tense and plurality.

We compared the search results from the term-based treatments to two treatments that also leveraged standards alignment data. In the STDA treatment, we used the same methodology as in CV but instead of using only the terms found in the original standard, we considered a term to be included in the standard if it was found in any other directly aligned standards. For example, in addition to

terms such as *earth*, *crust*, and *ocean*, we computed relevance using additional terms found in aligned standards; e.g., *earthquake*, *convection*, and *currents*. In the STRAND treatment we used terms from other parts of the AAAS strand which includes the original standard (see [5] for more on strands). This approach added *plate tectonics*, *waves*, and *sound* to the list of terms employed in the relevance computation. Table 2 lists the number of learning objects in the top 15 results which were judged to be relevant to the standard. Please note that the STDA treatment, which uses both terms and standards alignments, retrieved the most correct items.

Table 2. Number of correct results by treatment

Treatment – Relevance ranking is based on	Number Correct (out of 15)
CV – Identified key words and vocabulary	12
NP – Extracted noun phrases	13
STDA – CV + manual standards alignments	14
STRAND – CV + other standards in the AAAS strand	10

The queries we ran also had other interesting results. The 11 documents found using a simple *tectonic* word search all showed up even though the term *tectonic* does not appear in the target standard. The relevance scores computed in the NP treatment were higher for some items manually judged to be most relevant as compared to the scores of those same documents in the CV treatment. And the STRAND treatment retrieved some unexpected but possibly interesting documents related to sound and energy.

4. CONCLUSIONS

The preliminary exploration presented here documents the sparseness of a standards alignment matrix and suggests the usefulness of combining terms-based relevance with standard-to-standard alignments to support standards-based search.

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