

# **Automatic Mapping of Resources to Content Standards**

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## **Objectives of the Project**

- Explore effective strategy for metadata generation for educational materials
- Develop middleware tool for the automatic assignment of content standards and benchmarks

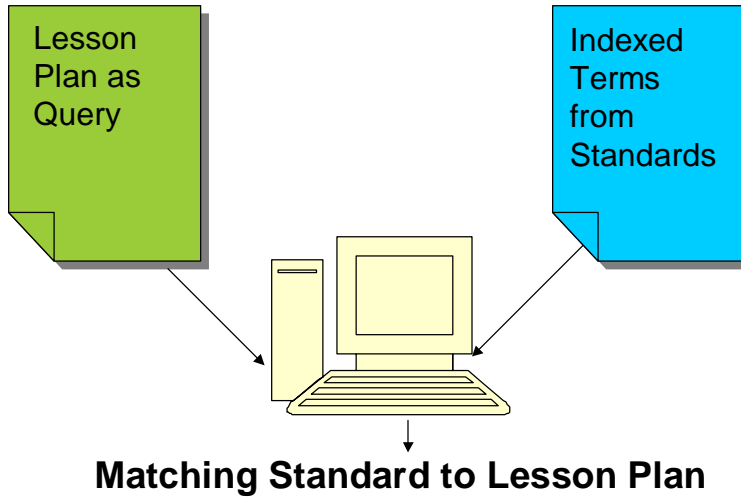
## Strategies Explored

- Automatic text categorization Problems
  - Sparse training data
  - Only 24% of Math and Science standards covered by more than 1 Lesson Plan
  - Lesson plans fit multiple categories
- Information retrieval

## Methodology

- Information Retrieval for standard assignment
  - Standards as *documents*
  - Educational materials such as lesson plans as *queries*
  - Standard assignment as *matching*
  - Information retrieval experiments for evaluation

## Standard Assignment as Retrieval Process



## Procedures

- Document processing
  - Splitting, Document expansion, and NLP processing
- Query processing
  - Stemming, query weighting, query filtering, formulation
- Indexing & Retrieval
  - Phrases as well as words as index terms
  - CNLP search engine

## Splitting

- Converting large Standard document into short passages
- Name each passage with name reflecting classification code of that particular benchmark.

```
<ACH_COMPENDIX_SUBJECT> Math </ACH_COMPENDIX_SUBJECT>
<ACH_COMPENDIX_DATE_TIME> 2002-01-06 00:55:14
</ACH_COMPENDIX_DATE_TIME> <ACH_STANDARDS_CATEGORY>
<ACH_COMPENDIX_STANDARDS_CATEGORY_TEXT>Problem Solving
</ACH_COMPENDIX_STANDARDS_CATEGORY_TEXT>
<ACH_COMPENDIX_STANDARDS_CATEGORY_NUMBER>1
</ACH_COMPENDIX_STANDARDS_CATEGORY_NUMBER> <ACH_
COMPENDIX_SECTION> <ACH_COMPENDIX_TRIPLET> 1.1.1
</ACH_COMPENDIX_TRIPLET><ACH_COMPENDIX_BENCHMARK
_TEXT >Draws pictures to represent problems </ACH_COMPENDIX
_BENCHMARK_TEXT>... <ACH_COMPENDIX_VOCAB>
<ACH_COMPENDIX_VOCAB_PAIR>
<ACH_COMPENDIX_VOCAB_LETTER> A </ACH_COMPENDIX
_VOCAB_LETTER> <ACH_COMPENDIX_VOCAB_WORD>pictorial
representation </ACH_COMPENDIX_VOCAB_WORD>
</ACH_COMPENDIX_VOCAB_PAIR> </ACH_COMPENDIX_VOCAB>
...</ACH_COMPENDIX_SECTION>.....
```

```
<DOC>
<URI>8.1.1.1.xml</URI>
<TEXT>
Math
Problem Solving
Draws pictures to represent
problems
pictorial representation
</TEXT>
</DOC>
```

## Document Expansion

- Expand the Standards with vocabulary from pre-assigned educational resources and other resources
- Boost Standard content

```
<DOC>
<URI>8.1.1.1.xml</URI>
<TEXT>
Math
Problem Solving
Draws pictures to represent
problems
pictorial representation
</TEXT>
</DOC>
```

```
<DOC><URI>8.1.1.1.xml</URI><TEXT>
Math
Problem Solving
Draws pictures to represent problems
pictorial representation
addition
subtraction
picture
representation
illustrate
illustration
depict
sketch
draw</TEXT></DOC>
```

## Query Formulation

- Generating queries by extracting important terms from the lesson plans
- Stemming
- Stopword removal
- Query filtering
- Query weighting

**Description:** Students can develop strategies for learning multiplication facts by finding patterns on a multiplication table.

**Goals:** Students will develop strategies for learning multiplication facts.

**Objectives:** Student will:

- discover patterns on a multiplication table
- create strategies for factors 4-9

**Materials:**

- Overhead Projector
- Multiplication tables for each student

**Procedure:** .....

ATH0043.html.xml.mM.penn

"multiplication"^29.1155 "pattern"^15.3802

"table"^12.5456 "strategy"^12.1264

"fact"^5.5522 "arithmetic"^4.9478

"group"^4.5062 "factor"^4.3505

"discover"^3.9928 "paper"^3.7378

"number"^3.6257 "row"^3.5783 "chart"^3.5065

"write"^3.4304 "block"^2.9737

"definition"^2.8437 "mathematics"^2.6861

"behavior"^2.6452 "circle"^2.5933 "

## Automatic Evaluation

- Manual evaluation is costly
- Developed test collection for automatic evaluation
- Relevance judgments for 297 queries (lesson plans)
- Very few relevant documents per query (75%  $\leq 3$ )
- Performance measure to fit the task
  - Precision/recall at  $n$ -th document level  
(  $n = 1, 2, 3 \dots 10$  )



## Information Retrieval Experiments

- Different ways for document processing
  - Expanded vs. non expanded standards
  - NLP processed vs. original standards
- Different ways for query processing
  - Words vs. phrases
  - Query size

## Retrieval Results on Math and Science Standards

Experiment	<i>N</i>	Relevant standard in top 10	Precision at rank 1	Recall at rank 1
Expanded, 15 terms	297	195	0.3468	0.1888
Not expanded 20 terms	297	222	0.3434	0.1915
Expanded, 20 terms	297	262	0.5657	0.3152
Expanded 25 terms	297	265	0.5623	0.3158

## Findings

- Standard expansion increased performance
- Query filtering increased performance
- Phrase extraction did not help performance
- Unsuccessful attempts (need further investigation)
  - Relevance feedback: no effect on performance
  - Topic-ranking: negatively affects performance
  - Using metadata: no effect on performance

## Failure Analysis

- Vocabulary gap between standards and lesson plans
  - standard contains abstract highly theoretical language, lesson plans contain specific language
- Query representation: missing important query terms:
  - challenge to extract an appropriate number of key terms from lesson plans, some of which may be quite long
- Incompleteness or error in the relevance judgment file

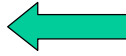
## Vocabulary Gap – An Example

### lesson plan A

..... Inform the students that they will have to find a place to live. Have several Newspapers ready for them to find a suitable place to fit their "families". They have to write a check to you for rent, deposit, etc. The students will also have to write out checks for all of their bills, extra spending, or anything extra that might pop up.

### Standard 8.1.3.4.xml

Math  
Problem Solving  
Formulates a problem, determines information required to solve the problem, chooses methods for obtaining this information, and sets limits for acceptable solutions  
problem solving  
problem formulation  
information  
method  
data collection  
limit  
solution  
solving problem  
analyze



**Lesson plan A  
should match  
Standard  
8.1.3.4.xml.**

**However, none  
of the language  
overlaps**

## Ongoing Research

- Manual Evaluation of Standard Assignment

## Future Research

- Filling the gap
  - High level understanding of the lesson plans – develop summarization capability for educational resources.
  - Expanding the Standards employing appropriate knowledge
  - Expand matching to allow semantic alternatives
- Improving query representation
  - Template querying
- Machine learning with larger training set

<http://www.cnlp.org>

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