Recommending Learning materials to Students by Identifying their Knowledge Gaps

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Research Question

How to recommend learning materials to students in order to improve their learning performance?

Our solution:

- Identify the "gaps" in students' knowledge in the subject matter
- Fill in these gaps by recommending appropriate learning materials

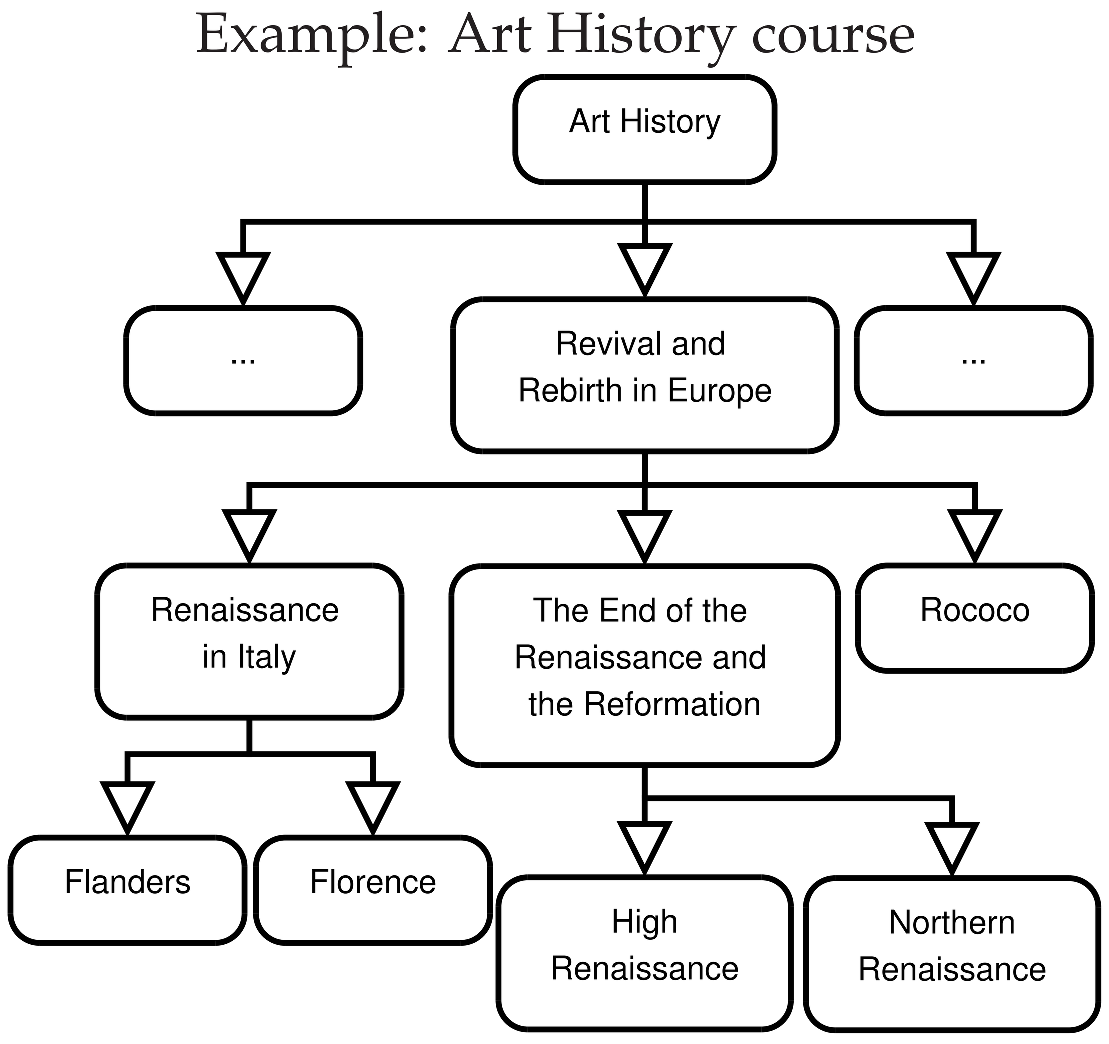
The Gap Filling Method

1. Build Taxonomy of topics for each course
2. Build Library of remedial materials
3. For each item in the library identify the list of corresponding course topics
4. For each quiz question in a course, identify the list of corresponding course topics
5. Build students' Performance profiles
6. Identify *gaps* in student's profile
7. Prepare Recommendations

Each of the items is explained below.

1: Taxonomy

Example: Art History course



Each topic in the taxonomy has a name and a text of obligatory reading materials.

2: Library

The popular reading materials for the course including textbooks, scientific papers, online articles, web pages, etc.

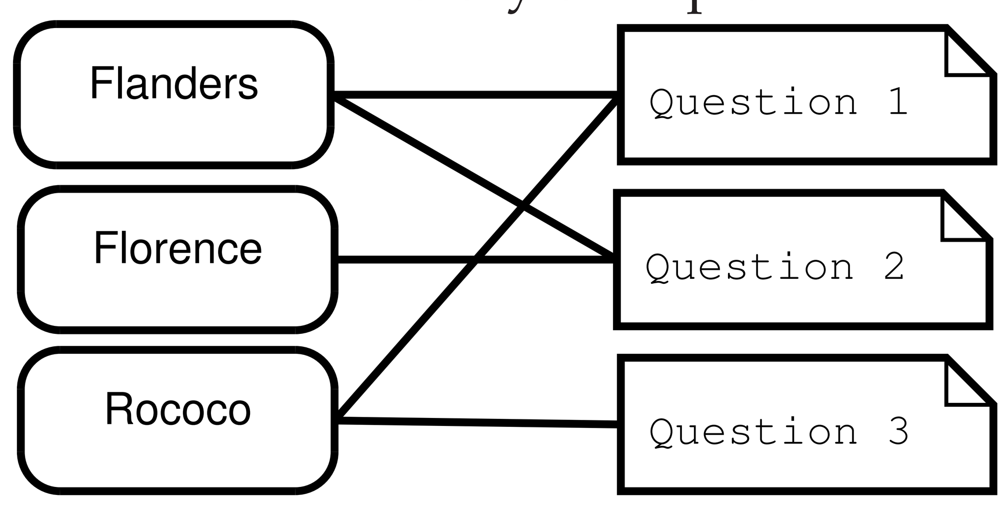
3: Item - Topic Relation

For each topic in the course taxonomy identify the "unit of knowledge" in the library (e.g., book chapter) corresponding to it in the best way (e.g. using the TF-IDF-based measure).

4: Quiz - Topic Relation

For each topic from the course taxonomy we determine the list of quiz questions corresponding (e.g using the TF-IDF-based measure).

Art History example



5: Performance Profile

For each student and a course offering determine how well the student understood all the material in the course i.e., calculate *performance score* for each topic in the course taxonomy specifying how well the student understood a particular topic.

Example:

$Flanders$: $[(q_1,✗),(q_2,✓),(q_3,✗)]$,
thus $Flanders \rightarrow 0.33$

$Florence$: $[(q_1,✗),(q_2,✗),(q_3,✓),(q_4,✓),(q_5,✓)]$,
thus $Florence \rightarrow 0.6$

$Rococo$: $[(q_1^R,✓),(q_2^R,✓),(q_3^R,✗),(q_4^R,✓)]$,
thus $Rococo \rightarrow 0.75$

6: Gaps Identification

- For each topic in the course taxonomy, we identify students knowledge gaps in the course, i.e., **identify those topics on which they performed poorly**.
- A student has a knowledge gap for a topic if either
  - the *performance score* of a student for this topic is low (i.e., below a certain threshold level) or
  - the student has knowledge gaps for a sufficient number of subtopics of that topic.

7: Recommendations

Given:

- the structure of the course,
- the identified gaps in student knowledge in the class,
- the links between the topics in the course taxonomy and the supplemental reading materials from the library

Goal:

- provide recommendations of the supplementary reading materials to the students in order to close these knowledge gaps.

Empirical Study (A/B test)

Data:

- An on-line university
- 35 different courses including Computer Science (12), Business (15) and General Studies (8)
- 2 semesters of 9 weeks each
- 530 students from all over the world
- 966 enrollments in total (i.e., 966 student/course pairs).

Experimental Design

Randomly spilt the students into 3 groups:

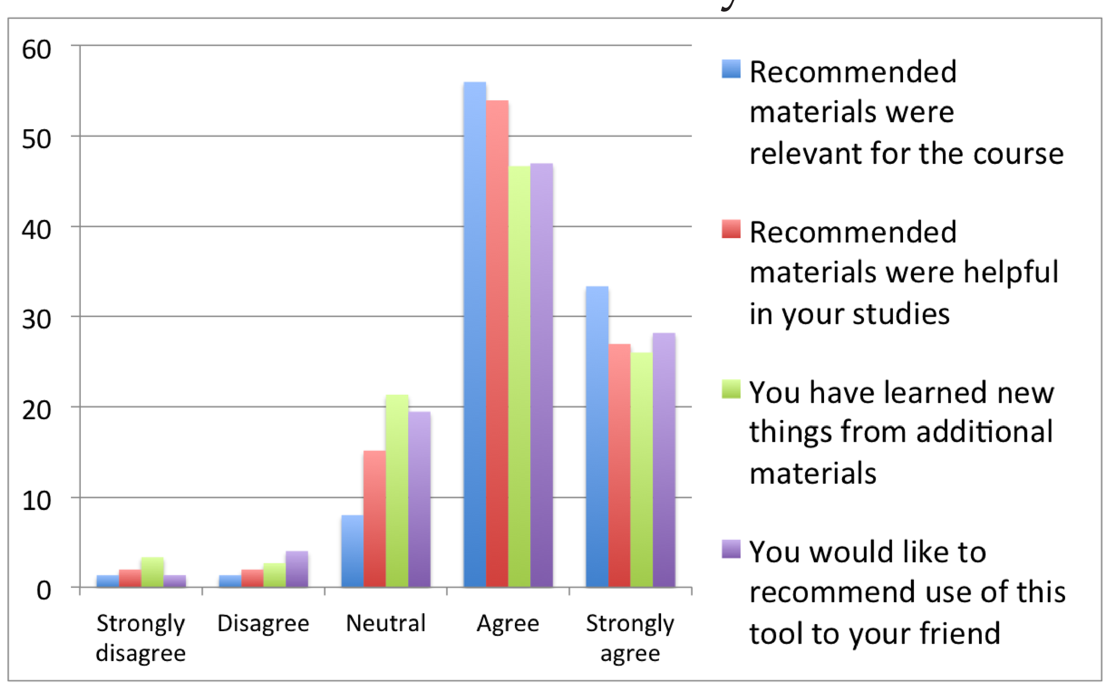
Group 1: did not receive any recommendations (a **control group**)

Group 2: received a standard set of **non-personalized** recommendations

Group 3: received **personalized** recommendations (as described above).

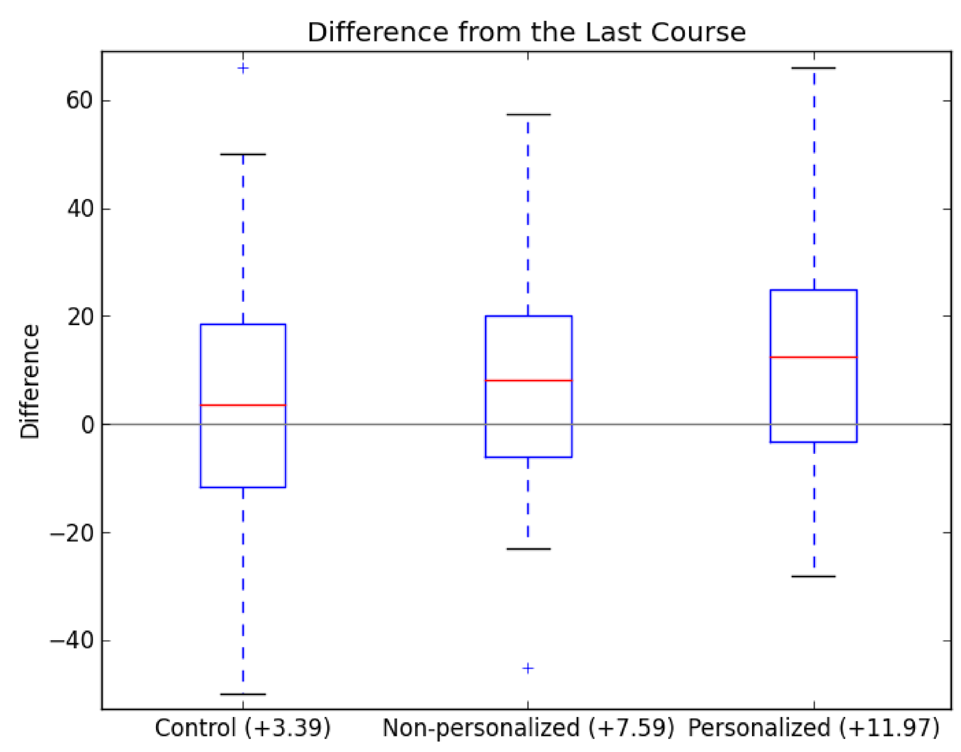
Results

Most of the students liked our recommendations and think that they were useful:



We compare performance of students from Group 1 and performance of those students from Groups 2 and 3 that visited at least one recommended material during the semester.

Distribution of differences between performances of actual grades on the final exam in current course and in the previous one.



Conclusions:

(1) Students liked our recommendations, and found them to be useful.

(2) Personal recommendations lead to better performance of students on final exams (and hence better grades) vs. control group and non-personalized recommendations.