Understanding Engagement and Sentiment in MOOCs using Probabilistic Soft Logic (PSL)

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UC Santa Cruz

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MOOC Domains

Characterized by:

- Rich Socio-Behavioral Data
- Rich Outcomes Space
- Opportunity (and Need for!!) Interventions
Overview

Data
- 14 different UMD courses spanning varied disciplines:
  - Business, Sciences, History, Computer Science, Philosophy, and Religion
  - Includes most popular courses, Innovative Ideas and Android, which have run successfully for several iterations and attract a large number of participants each offering
- Courses have on average 100,000 students, 10,000 posts
- On average, # latent + target variables ≈ 400,000
- Largest course has students ~230,000 and 50,000 posts
- Temporal data for 34 repeated offerings of Business course and 15 offerings of CS course

Latent Variable Models
- Engagement, sentiment, topics, fine-grained course aspects
- Validated on outcome, completion and aspect prediction
- Used for exploratory and descriptive analysis

References: Ramesh, PhD Thesis 2016, Ramesh et al., ACL 2015, Ramesh et al., AAAI 2014, Ramesh et al., L@S 2014, Ramesh et al., BEA 2014.
Modeling Approach
Probabilistic Soft Logic (PSL)

A probabilistic programming language for collective probabilistic inference problems
- Predicate = relationship or property
- Atom = (continuous) random variable
- Rule = capture dependency or constraint
- Set = define aggregates

PSL Program = Weighted Rules + Input DB

PSL Foundations

- PSL makes large-scale reasoning scalable by mapping logical rules to convex functions and defines a hinge-loss Markov Random field:

\[
P(Y \mid X) = \frac{1}{Z} \exp \left[ - \sum_{j=1}^{m} w_j \max\{\ell_j(Y, X), 0\}^{p_j} \right]
\]

- Three principles justify this mapping [Bach et al., AIStats 15]:
  - LP programs for MAX SAT with approximation guarantees [Goemans & Williamson 94]
  - Pseudomarginal LP relaxations of Boolean Markov random fields [Wainwright et al. 02]
  - Łukasiewicz logic, a logic for reasoning about continuous values [Klir & Yuan 95]
PSL Summary in a Slide

- PSL is a probabilistic programming language that supports declarative features, collective reasoning and lifted models.
- MAP Inference in PSL translates into convex optimization problem -> inference is really fast. Inference further enhanced with state-of-the-art optimization and distributed processing paradigms such as ADMM & GraphLab -> inference even faster.
- Outperforms discrete MRFs in speed and often accuracy.
- Learning methods for rule weights & latent variables.
- Good fit for many structured prediction problems in NLP, computer vision, social computing, information integration, knowledge construction, and more.
- PSL is open-source, code, data, tutorials available online.
Application Domains

- Computational Biology & Health Informatics
  - Drug-target prediction
  - Drug interaction prediction
- Computational Social Science
  - Social trust prediction
  - Latent Group Modeling in Twitter
  - Learner engagement in MOOCs
  - Inferring bias in political discourse
  - Psychological modeling on online social networks
- Computer Vision
  - Low-level image reconstruction
  - Activity recognition in Video
- Information Integration & Extraction
  - Entity resolution
  - Knowledge graph identification
  - Ontology alignment & schema mapping
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  - Activity recognition in Video

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  - Entity resolution
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  - Ontology alignment & schema mapping
Latent-Variable Models
Student Engagement

Ramesh et al., AAAI 2014
Student Engagement in MOOCs

Engagement in MOOCs different from classrooms

How do students engage with the MOOC?
Problem: Modeling Student Engagement

- Large number of registrants
- Low completion rate

Problem: How to model student engagement in MOOCs?

Model engagement using
- Online behavior
- Linguistic Analysis of forum posts
- Structural attributes from forum interactions
- Temporal attributes modeling continuous behavior
Three forms of engagement: active engagement, passive engagement, and disengagement

Two measures of student success: course performance and course completion

Two models: direct and latent
HL-MRF Course Success Prediction Models

- **Direct**
  - Dependencies among observed variables predict course success
"John posts positive sentiment posts indicates course completion"

Observed Features: \( \text{POSTS}(“John”, P) \land \text{POSITIVE}(P) \) 

implies 

Target Variable: \( \text{COURSE-COMPLETION}(“John”) \)

"Mary votes on positive sentiment indicates course completion"

Observed Features: \( \text{VOTES}(“Mary”, P) \land \text{POSITIVE}(P) \) 

implies 

Target Variable: \( \text{COURSE-COMPLETION}(“Mary”) \)
PSL Course Success Prediction Models

- **PSL-LATENT**
  - Latent variable capturing engagement types
    - Active Engagement, Passive Engagement, Disengagement
  - Dependencies between *observed behavior* and *course-success* through latent engagement type
PSL-LATENT

“John posts in forums indicates his active engagement in class”

Observed Features \implies \text{Latent Engagement Variables}

\text{POSTS}(“John”, P) \land \text{POSITIVE}(P) \Rightarrow \text{ENGAGEMENT-ACTIVE}(“John”)

“Mary views lectures, views forum posts indicates her passive engagement in class”

Observed Features \implies \text{Latent Engagement Variable}

\text{VIEW-LECTURE}(“Mary”, L) \land \text{VIEW-FORUM}(“Mary”, P) \Rightarrow \text{ENGAGEMENT-PASSIVE}(“Mary”)
Experimental Results: Performance

<table>
<thead>
<tr>
<th>Course</th>
<th>Model</th>
<th>certificate</th>
<th>~certificate</th>
<th>AUC-ROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISRUPTIVE TECHNOLOGIES (BUSINESS)</td>
<td>LECTURE-RANK</td>
<td>0.630</td>
<td>0.421</td>
<td>0.512</td>
</tr>
<tr>
<td></td>
<td>DIRECT</td>
<td>0.739</td>
<td>0.546</td>
<td>0.667</td>
</tr>
<tr>
<td></td>
<td>LATENT</td>
<td>0.759</td>
<td>0.575</td>
<td>0.692</td>
</tr>
<tr>
<td>WOMEN &amp; CIVIL RIGHTS (HISTORY)</td>
<td>LECTURE-RANK</td>
<td>0.263</td>
<td>0.761</td>
<td>0.503</td>
</tr>
<tr>
<td></td>
<td>DIRECT</td>
<td>0.794</td>
<td>0.881</td>
<td>0.862</td>
</tr>
<tr>
<td></td>
<td>LATENT</td>
<td>0.922</td>
<td>0.950</td>
<td>0.948</td>
</tr>
<tr>
<td>GENE &amp; HUMAN CONDITION (SCIENCE)</td>
<td>LECTURE-RANK</td>
<td>0.503</td>
<td>0.482</td>
<td>0.476</td>
</tr>
<tr>
<td></td>
<td>DIRECT</td>
<td>0.814</td>
<td>0.755</td>
<td>0.817</td>
</tr>
<tr>
<td></td>
<td>LATENT</td>
<td>0.943</td>
<td>0.879</td>
<td>0.931</td>
</tr>
</tbody>
</table>

Performance: predicting whether a student earns a certificate
Area under Curve (AUC) scores for predicting **certificate** and **~certificate**

LATENT PSL Model performs better at predicting performance
Experimental Results: Course Completion

<table>
<thead>
<tr>
<th>Course</th>
<th>Model</th>
<th>course-completion</th>
<th>dropout</th>
<th>AUC-ROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISRUPTIVE TECHNOLOGIES (BUSINESS)</td>
<td>LECTURE-RANK</td>
<td>0.333</td>
<td>0.998</td>
<td>0.957</td>
</tr>
<tr>
<td></td>
<td>DIRECT</td>
<td>0.393</td>
<td>0.997</td>
<td>0.936</td>
</tr>
<tr>
<td></td>
<td>LATENT</td>
<td><strong>0.546</strong></td>
<td><strong>0.998</strong></td>
<td><strong>0.969</strong></td>
</tr>
<tr>
<td>WOMEN &amp; CIVIL RIGHTS (HISTORY)</td>
<td>LECTURE-RANK</td>
<td>0.508</td>
<td>0.995</td>
<td>0.946</td>
</tr>
<tr>
<td></td>
<td>DIRECT</td>
<td>0.565</td>
<td>0.995</td>
<td>0.940</td>
</tr>
<tr>
<td></td>
<td>LATENT</td>
<td><strong>0.816</strong></td>
<td><strong>0.998</strong></td>
<td><strong>0.983</strong></td>
</tr>
<tr>
<td>GENE &amp; HUMAN CONDITION (SCIENCE)</td>
<td>LECTURE-RANK</td>
<td>0.688</td>
<td>0.984</td>
<td>0.938</td>
</tr>
<tr>
<td></td>
<td>DIRECT</td>
<td>0.757</td>
<td><strong>0.985</strong></td>
<td><strong>0.939</strong></td>
</tr>
<tr>
<td></td>
<td>LATENT</td>
<td><strong>0.818</strong></td>
<td><strong>0.985</strong></td>
<td><strong>0.944</strong></td>
</tr>
</tbody>
</table>

**LATENT** Model performs better at predicting course completion and dropout.

Completion harder to predict due to high percentage of dropouts.
## Early Prediction

<table>
<thead>
<tr>
<th>Course</th>
<th>Model</th>
<th>start</th>
<th>mid</th>
<th>start-mid</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISRUPTIVE TECHNOLOGIES</td>
<td>LECTURE-RANK</td>
<td>0.204</td>
<td>0.280</td>
<td>0.269</td>
</tr>
<tr>
<td>(BUSINESS)</td>
<td>DIRECT</td>
<td>0.304</td>
<td>0.400</td>
<td>0.372</td>
</tr>
<tr>
<td>Woment &amp; Civil Rights</td>
<td>LECTURE-RANK</td>
<td>0.417</td>
<td>0.454</td>
<td>0.451</td>
</tr>
<tr>
<td>(HISTORY)</td>
<td>DIRECT</td>
<td>0.538</td>
<td>0.518</td>
<td>0.533</td>
</tr>
<tr>
<td>WOMEN &amp; CIVIL RIGHTS</td>
<td>LECTURE-RANK</td>
<td>0.552</td>
<td>0.648</td>
<td>0.650</td>
</tr>
<tr>
<td>(HISTORY)</td>
<td>DIRECT</td>
<td>0.647</td>
<td>0.755</td>
<td>0.692</td>
</tr>
<tr>
<td>GENE &amp; HUMAN CONDITION</td>
<td>LECTURE-RANK</td>
<td>0.705</td>
<td>0.755</td>
<td>0.778</td>
</tr>
<tr>
<td>(SCIENCE)</td>
<td>DIRECT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>LATENT</td>
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<td></td>
</tr>
</tbody>
</table>

**Early prediction** helps identify students engaged with the MOOC

*LATENT* outperforms *DIRECT* and *LECTURE-RANK* in early prediction
Topics & Sentiment

Ramesh et al., 9th ACL Workshop on Innovative Use of NLP for Building Educational Applications (BEA), 2014
## Example MOOC Posts

<table>
<thead>
<tr>
<th>MOOC Post</th>
</tr>
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<tbody>
<tr>
<td>Our history keeps silence about <strong>violence</strong> in families, <strong>contempt</strong> and <strong>unfair</strong> treatment of women.</td>
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<td>I am from New York as well! Really <strong>love</strong> the city!</td>
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<td>What I <strong>love</strong> about the lesson is how music influences social change. So many <strong>great</strong> songs can <strong>motivate</strong> change in people and society.</td>
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</tr>
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<td>MOOC Post</td>
<td>Sentiment</td>
</tr>
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MOOC Forum Categories

- Discussions about course material (academic)
- Meta-level discussions about course: logistics and feedback (logistics)
- Other general discussions: Introductions, Study Groups (social)
Topic Modeling for MOOC Forums

• Unsupervised methods are useful
  – Many classes, less commonality between classes
  – LDA, variants of LDA are good choices

• Sample LDA Topics
  • newspaper, paper, model, business, print, course, assignments, grade
  • time, grading, different, course, class, major, submit, product, like
  • companies, interesting, class, thanks, print, far, wonder, article

• Words in LOGISTICS get mixed up with ACADEMIC words

• SeededLDA for MOOCs
  – Many classes but a common set of seed words
  – Course-specific seed words from syllabus

Jagarlamudi et al. 2010
SeededLDA for MOOC Forums

- Seed topics with possible words from logistics and social posts
  
  **LOGISTICS**: problem, issue, lecture, assignment, question
  **SOCIAL**: introduction, study, group, coursera, learning

- Seed academic topics with words from syllabus
  
  **Course - Disruptive Technologies**: disruptive, technology, innovation, survival,
  **Course - Women and Civil Rights**: women, civil, rights, movement, political, …
  **Course – Gene and the Human Data**: gene, sequence, disease, immunity, …

- $k$ non-seeded topics to capture other topics
Adding Topics as Features

DIRECT +
Behavioral
Structural
Linguistic
Sentiment
Topic of posts
Temporal

Course Success

Topic as features in our success prediction models
Encoding Topics in PSL Rules

- LOGISTICS posts with negative sentiment implies dropping out
  \[
  \text{posts(John, P) } \land \text{ topic(P, LOGISTICS) } \land \text{ negative(P)} \rightarrow \neg \text{success(John)}
  \]

- SOCIAL posts indicate dropping out
  \[
  \text{posts(Mary, P) } \land \text{ topic(P, SOCIAL) } \rightarrow \neg \text{success(Mary)}
  \]

- ACADEMIC posts that receive positive feedback indicate survival
  \[
  \text{posts(Lily, P) } \land \text{ topic(P, ACADEMIC) } \land \text{ upvote(P)} \rightarrow \text{success(Lily)}
  \]

- Students posting in similar topics have similar survival tendencies
  \[
  \text{posts(John, P1) } \land \text{posts(Mary, P2) } \land \text{ topic(P1, ACADEMIC) } \land \text{ topic(P2, ACADEMIC) } \land \text{ success(John)} \rightarrow \text{success(Mary)}
  \]
## Experimental Results

<table>
<thead>
<tr>
<th>COURSE</th>
<th>MODEL</th>
<th>AUC-PR (POS)</th>
<th>AUC-PR (NEG)</th>
<th>AUC-ROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISR</td>
<td>DIRECT</td>
<td>0.76</td>
<td>0.62</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>DIRECT+TOPIC</td>
<td>0.79</td>
<td>0.64</td>
<td>0.71</td>
</tr>
<tr>
<td>WOMEN</td>
<td>DIRECT</td>
<td>0.65</td>
<td>0.89</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>DIRECT+TOPIC</td>
<td>0.67</td>
<td>0.90</td>
<td>0.83</td>
</tr>
<tr>
<td>GENE</td>
<td>DIRECT</td>
<td>0.87</td>
<td>0.78</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>DIRECT+TOPIC</td>
<td>0.89</td>
<td>0.79</td>
<td>0.88</td>
</tr>
</tbody>
</table>

- 3 Courses: Disruptive Technologies, Women & Civil Rights, and Gene & Human Condition
- Including topics improves AUC-PR and AUC-ROC for predicting student survival
Negative Sentiment in ACADEMIC VS LOGISTICS

Negative sentiment in ACADEMIC post (survived student)

- Our history keeps silence about **violence** in families, **contempt** and **unfair** treatment of women.

Negative sentiment in LOGISTICS post (dropped out student)

- The videos are totally **unsynchronized**. It's really **confusing** to hear the instructor talking about something while the image is telling a whole different story.

ACADEMIC posts with negative sentiment often indicate student engagement, hence student completion
Instructor Intervention in LOGISTICS posts

Unanswered LOGISTICS posts (dropped out student)

- There are some mistakes on quiz 2. Questions 3, 5, and 15 mark you wrong for answers that are correct.

Answered LOGISTICS posts (survived student)

- Lecture slides for the videos (week 5) don’t open (at all)
- Hopefully the Terrell reading and the Lecture PowerPoints now open for you. Thanks for reporting this.

Answering logistics questions leads to increased student satisfaction, hence survival

Finding LOGISTICS posts and the problems mentioned automatically can help instructor intervention and avoid dropout
Fine-grained Aspect-Sentiment Models

Ramesh et al., ACL 2015
# Sentiment in MOOC Posts

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<td><strong>Negative</strong></td>
</tr>
<tr>
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<td><strong>Positive</strong></td>
</tr>
<tr>
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<td><strong>Neutral</strong></td>
</tr>
<tr>
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<td><strong>Positive</strong></td>
</tr>
<tr>
<td>When is quiz 4 due?</td>
<td><strong>Neutral</strong></td>
</tr>
</tbody>
</table>

**Logistics**
## Aspect-Sentiment in MOOC Posts

<table>
<thead>
<tr>
<th>MOOC Post</th>
<th>Sentiment</th>
<th>Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our history keeps silence about <strong>violence</strong> in families, <strong>contempt</strong> and <strong>unfair</strong> treatment of women.</td>
<td>Negative</td>
<td>Lecture-Content</td>
</tr>
<tr>
<td>I am from New York as well! Really <strong>love</strong> the city!</td>
<td>Positive</td>
<td>Social</td>
</tr>
<tr>
<td>What I <strong>love</strong> about the lesson is how music influences social change. So many <strong>great</strong> songs can <strong>motivate</strong> change in people and society.</td>
<td>Positive</td>
<td>Lecture-Content</td>
</tr>
<tr>
<td>The video is very <strong>jumpy</strong>. I <strong>hated</strong> the experience.</td>
<td>Negative</td>
<td>Lecture-Video</td>
</tr>
<tr>
<td>Will everyone get a certificate or only people in the signature track?</td>
<td>Neutral</td>
<td>Certificate</td>
</tr>
<tr>
<td>Will subtitles be made available for the lectures for this week? I <strong>liked</strong> the transcripts from last week.</td>
<td>Positive</td>
<td>Lecture-Subtitles</td>
</tr>
<tr>
<td>When is quiz 4 due?</td>
<td>Neutral</td>
<td>Quiz-Deadlines</td>
</tr>
</tbody>
</table>
Aspect Hierarchy

- Aspects
  - Lecture
  - Quiz
  - Certificate
  - Social
Aspect Hierarchy

Aspects

- Lecture
- Quiz
- Certificate
- Social

Coarse Aspects
Aspect Hierarchy

Aspects

Lecture
- Content
- Video
- Audio
- Lecturer
- Subtitles

Quiz
- Content
- Submission
- Deadlines
- Grading

Certificate

Social

http://psl.umiacs.umd.edu
Aspect Hierarchy

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Fine Aspects

http://psl.umiacs.umd.edu
Predicting Fine-grained Aspects: Challenges

- Labeled data hard to obtain
  - 5-10% posts contain problems
  - Unsupervised/weakly supervised approaches desirable
  - Privacy concerns around data sharing

- Aspects differ across courses
  - Careful mining of posts required to come up with exhaustive aspect categories
  - System not fine-tuned to one course, but can adapt across courses
Aspect Sentiment Prediction Models

- **Seeded LDA**
  - 3 seeded LDA models for coarse aspect, fine aspect and sentiment

- **PSL-Joint**
  - Combining features
    - Multiple seeded LDA features
  - Encoding dependencies
    - Hierarchical dependence between aspects
    - Dependence between aspect and sentiment
Empirical Evaluation

- Twelve courses across multiple disciplines
  - Disruptive Technologies (Business)
  - Gene and Human Condition (Science)
  - Women and the Civil Rights Movement (History)
  - Developing Innovative Ideas for New Companies (Business)
  - Android Applications (Computer Science)
  - Making Better Group Decisions (Philosophy)
  - Religious Tolerance in Religious Society (History)

- Dataset contains
  - Posts sampled from 12 courses
  - Crowdsourced labels for sentiment, coarse aspect, and fine aspect (evaluation)
Evaluation: Coarse Aspect and Sentiment

F1 scores for SeededLDA and PSL-Joint for coarse aspects

<table>
<thead>
<tr>
<th>Model</th>
<th>Lecture</th>
<th>Quiz</th>
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<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeededLDA</td>
<td>0.632</td>
<td>0.657</td>
<td>0.459</td>
<td>0.654</td>
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<tr>
<td>PSL-Joint</td>
<td>0.630</td>
<td>0.706</td>
<td>0.621</td>
<td>0.659</td>
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</tbody>
</table>

F1 scores for SeededLDA and PSL-Joint for sentiment

<table>
<thead>
<tr>
<th>Model</th>
<th>Positive</th>
<th>Negative</th>
<th>Neutral</th>
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</thead>
<tbody>
<tr>
<td>SeededLDA</td>
<td>0.182</td>
<td>0.517</td>
<td>0.356</td>
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<tr>
<td>PSL-Joint</td>
<td>0.189</td>
<td>0.615</td>
<td>0.434</td>
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</table>
## Evaluation: Fine Aspect

**Fine-grained aspects under coarse aspect lecture**

<table>
<thead>
<tr>
<th>Model</th>
<th>Content</th>
<th>Video</th>
<th>Audio</th>
<th>Lecturer</th>
<th>Subtitles</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeededLDA</td>
<td>0.08</td>
<td>0.240</td>
<td>0.684</td>
<td>0.06</td>
<td>0.397</td>
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<tr>
<td>PSL-Joint</td>
<td>0.410</td>
<td>0.485</td>
<td>0.582</td>
<td>0.323</td>
<td>0.461</td>
</tr>
</tbody>
</table>

**Fine-grained aspects under coarse aspect quiz**

<table>
<thead>
<tr>
<th>Model</th>
<th>Content</th>
<th>Submission</th>
<th>Deadlines</th>
<th>Grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeededLDA</td>
<td>0.011</td>
<td>0.437</td>
<td>0.214</td>
<td>0.514</td>
</tr>
<tr>
<td>PSL-Joint</td>
<td>0.36</td>
<td>0.416</td>
<td>0.611</td>
<td>0.550</td>
</tr>
</tbody>
</table>
Interpreting PSL-Joint Predictions

“There is a typo or other mistake in the assignment instructions (e.g., essential information omitted).”

SeededLDA Prediction: Lecture-content
PSL-Joint Prediction: Quiz-content

“Thanks for the suggestion about downloading the video and referring to the subtitles. The audio is barely audible, even when the volume is set to 100%”

SeededLDA Prediction: Lecture-subtitles
PSL-Joint Prediction: Lecture-audio
Topic Evolution Models
Data

- **Business Course**: 34 iterations

- **CS Course**: 15 offerings, 9 total iterations

![Graphs showing number of students and posts across iterations for both courses]
Business Course: Primary Use of Forums

Evolution of social, issue and technical topics across iterations

![Graph showing the evolution of social, issue, and technical posts across iterations. Social posts dominate the forums across iterations.](http://psl.umiacs.umd.edu)
Business Course: Primary Use of Forums

Evolution of social, issue and technical topics across iterations

Analyzing the percentage of social, issue, and technical posts in the total number of posts in each iteration, we observe that the forums are primarily used for socializing and discussing technical content in the later iterations as the issue posts decline steadily, dropping to less than 10% after 30 iterations. Analyzing the number of social and issue posts per student, we observe that all three categories increase steadily for the initial iterations and then decline, indicating that fewer students participate in the forums as the course stabilizes.

6.4.1.2 Dominating Course Elements

Unlike most classroom courses, online courses attract diverse sets of students with varied interest and expectations from the course. Of these, three popular types of students include:

- Social posts dominate the forums across iterations
- Followed by technical posts
- Social posts dominate the forums across iterations

Followed by technical posts

Figure 6.3: Business course: change in social and issue posts across iterations
Business Course: Primary Use of Forums

Evolution of social, issue and technical topics across iterations

Forums mostly used for socializing and course-related discussions in later iterations

Issues decline significantly, falling to negligible numbers after 20 iterations

Followed by technical posts

Social posts dominate the forums across iterations
CS Course: Primary Use of Forums

Evolution of social, issue and technical topics across iterations

Social posts are more prominent in the early iterations, but fall lower than issue and technical posts toward the end.
CS Course: Primary Use of Forums
Evolution of social, issue and technical topics across iterations

Technical posts dominate the course across all iterations.

Social posts are more prominent in the early iterations, but fall lower than issue and technical posts toward the end.

Evolution of social, issue and technical topics across iterations.
CS Course: Primary Use of Forums

Evolution of social, issue and technical topics across iterations

Technical posts dominate the course across all iterations.

Social posts are more prominent in the early iterations, but fall lower than issue and technical posts toward the end.

Issue posts more significant in later iterations.
Effectiveness of Interventions: Coaching
High-school MOOCs

- Performance of MOOC students
- Effectiveness of coaching & forums
- Predictive behaviors for post-test performance (AP exam)

Tomkins et al., EDM 2016
Discussion & Summary
Socio-Behavioral Modeling in Education

- Requires rich models that capture content, behavior and outcomes
- Latent variables important
  - Engagement, sentiment, topics
  - Outcomes to validate latent modeling
    - Course completion, performance, response
- Opportunities
  - mix data-driven course-specific modeling with pedagogical knowledge-driven modeling
  - Direct interventions
Thank You!

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