

# The Data and Algorithms that Power AskOski

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School of Information  
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Computational Approaches to  
Human Learning (CAHL) research lab

GRADUATE SCHOOL OF EDUCATION



UC Berkeley School of Information

# What is AskOski today?

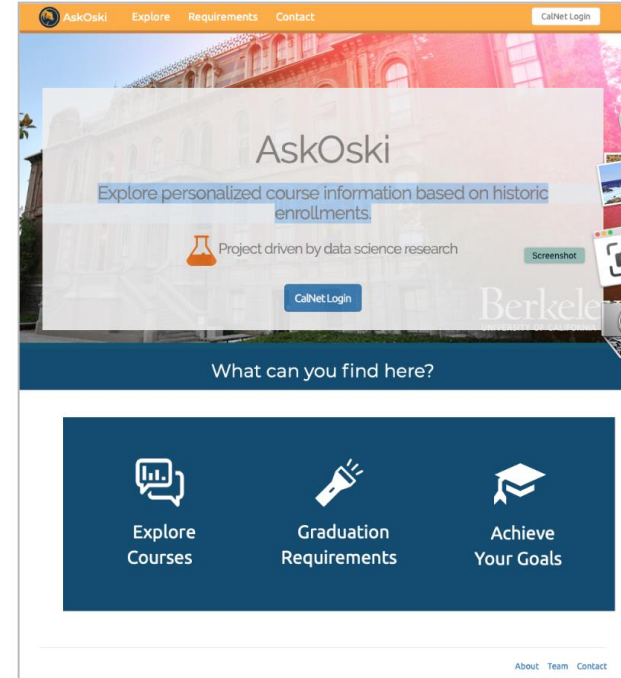
## AskOski

**AskOski** provides personalized course recommendations to students based on:

- The user's attributes and filters
- Historic enrollments at Berkeley

AskOski uses **machine learning** to allow students to:

- **Explore Courses** based on a favorite course
- Find courses that satisfy personal **graduation requirements**



Description from UCB Usability Workshop Feedback

Why are recommender systems needed in  
higher education?

# Motivation: Graduation planning is hard

**Laney College**  
**General Education Requirements for Local AA/AS Degrees**  
**2018-2019 Advising Form**

Student's Name (Please Print): \_\_\_\_\_

Last First Middle Student ID # Major

Legend: R=Remaining IP=In Progress C=Completed U=Units G=Grade

**OVERALL REQUIREMENTS**  
Candidates for the Associate Degree must complete at least 60 units to include courses in a Major, General Education, and Electives, as necessary (see catalog for details).

- A minimum grade-point average of 2.0 ("C") is required in **EACH** of the following:
  - Overall grade-point average
  - General Education Requirements
- A minimum grade of "C" or better is required in **EACH COURSE** in the major, English Composition (Area 4a), and Mathematics (Area 4b).
- At least 12 units must be completed at Laney.
- Students must complete a minimum of 19 units distributed among Areas 1, 2, 3, 4a, 4b, 4c, 4d and 5.

**NOTES:** While a course might satisfy more than one General Education Requirement, it may not be counted more than once for this purpose (see exception for Ethnic Studies courses). PCCD will accept a course with a minimum of 4 quarter units to satisfy an area that requires 3 semester units, and a course with a minimum of 1.5 quarter units to satisfy Area 4c which requires a minimum of 1 semester unit.

**GRADUATION EVALUATION**  
It is the student's responsibility to file a "Petition for an Associate Degree" by the deadline specified in the College Academic Calendar, (available in the class schedule or website). Students should file the petition once all course requirements are completed or final courses are in progress. Official transcript of any course work completed outside Peralta District must be on file prior to requesting the evaluation or accompany the petition. Petitions are available in the [Admissions and Records Office](#) and must be completed by appointment with a counselor.

**AREA 1 – NATURAL SCIENCE**  
One course with a minimum value of 3 semester units from the following:  
**ANTHR** 1, 21  
**ASTR** 10  
**BIOL** 1A, 1B, 2, 3, 4, 10, 11, 20A, 20B, 24, 26  
**CHEM** 1A, 1B, 12A, 12B, 25, 30A, 30B  
**ECT** 1\*, 101  
**ENGIN** 100  
**GEOG** 1, 9, 18, 19  
**GEOL** 10  
**PHYS** 15, 20, 22  
**PHYS** 3A, 3B, 4A, 4B, 4C, 10, 99\*

\* Students will receive credit for one course only.

Course from other College: \_\_\_\_\_ External Exam: \_\_\_\_\_



**Passport**

Search for Classes

Enter Search Criteria

Search for Classes

Campuses: ☐ Alameda ☒ Laney ☐ Merritt ☐ Berkeley ☐ All

Select Term: 2019 Spring

Select at least 2 search criteria. Select Search to view your search results.

**Class Search**

Subject: Chemistry

Course Number: is exactly

☐ All ☐ Fee-Based ☐ Noncredit ☒ Undergraduate

☐ Show Open Classes Only

☐ Open Entry/Exit Classes Only

Session:

Mode of Instruction:

Course Attribute:

Additional Search Criteria

CLEAR SEARCH



4 class section(s) found

Class	Section	Days & Times	Room	Instructor	Meeting Dates	Status
CHEM 1B - GENERAL CHEMISTRY						
21477	L1-L1C	Mo/Wed/Fri 10:00AM - 11:50AM	L-A 239	Staff	01/22/2019 - 05/24/2019	Open
21478	L1-L1AB	Mo 1:00PM - 3:50PM	L-A 236	Staff	01/22/2019 - 05/24/2019	Open
21479	L2-L2C	Mo/Tu/Th 6:00PM - 7:50PM	L-A 233	Michelle Fossum	01/22/2019 - 05/24/2019	Wait List
21480	L3-L3AB	Tu/Th 8:00PM - 9:15PM	L-A 236	Michelle Fossum	01/22/2019 - 05/24/2019	Wait List

Satisfying a degree requirement at  
Laney Community College

# Motivation: Exploration is hard

- Where do I start?
- How are courses conceptually related?
- Am I ready to take a course in a completely different field?
- Will this course count for credit at the school I want to transfer to?



40% 4-year graduation rate (USA)

1:400 or 1:1000 student to adviser ratio

# Timeline of AskOski development

- 2015: \$600,000 in NSF grants awarded (IIS BIGDATA)
- 2016: First prototype of course recommender released at Berkeley
- 2017: Small scale user study of satisfaction and desired functionality
- 2018: Beginning of research and development of course exploration feature
- 2019: Beginning of research and development of requirement satisfaction feature
- 2019: User study on relevance of search “inferred keywords”
- **2020**: Explore, Requirements, Search, PLAN features live ([askoski.berkeley.edu](http://askoski.berkeley.edu))



Explore  
Courses



Graduation  
Requirements

SearchQ



## Graduation Requirements

# Timeline

- 2015: \$600,000 in NSF grants awarded
- 2016: First prototype of AskOski released
- **2017**: Small scale user study of satisfaction and desired functionality

Measure of acceptance	Construct	Average rating
If available, I would use the AskOski service in the future	Use intentions	<b>4.25</b>
I would recommend AskOski to a peer	Use intention	3.85
The AskOski interface is intuitive to use	Perceived ease of use	3.80
The AskOski service provided information I couldn't get elsewhere	Perceived usefulness	3.55
The AskOski service improved my comfort with enrollment planning	Overall satisfaction	3.55

Ratings are from 1 (strongly disagree) to 5 (strongly agree)



# Timeline

- 2015: \$600,000 in NSF grants awarded
- 2016: First prototype of AskOski released
- **2017**: Small scale user study of satisfaction and desired functionality

Student course selection priorities	Average rating
Satisfying major requirements	<b>4.85</b>
Graduating on time	4.25
Maintaining GPA	4.15
Intellectual enrichment	4.10
Career goals	4.05
Satisfying course prerequisites	4.05
Satisfying breadth requirements	3.80

Average ratings are on a scale from 1 (not important) to 5 (very important)

# Retrieving per-student degree audit info from SIS

Undergraduate Degrees	
ACADEMIC_PLAN_NM	list_coverage
Industrial Eng & Ops Rsch BS	100
Education UG	100
Environmental Eng Science BS	100
BioE/MSE Joint Major BS	100
Disability Studies UG	100
EECS/MSE Joint Major BS	100
Chem Eng/MSE Joint Major BS	100
EECS/NE Joint Major BS	100
Jewish Studies UG	100
ME/NE Joint Major BS	100
Environmental Sciences BS	97.22
Chemical Engineering BS	96.67
Chemistry BS	95
Chemical Biology BS	95
250AMU	94.87
MCB-Immunology BA	94.44
Development Studies BA	94.44
Slavic Lang & Lit BA	94.44
Cognitive Science BA	94.12

Percentage of searchable (not grey)  
requirements in AskOski

Electrical Eng & Computer Sci Requirements:  
[Select a Requirement or search](#)

----- NOT COMPLETED -----

Upper Division (R-0014) - LIMIT - EECS 151LA, 151LB

Upper Division (R-0014) - LIMIT - Grad Tech Courses

Ethics (R-0017) - Ethics

Lower Division (R-0013) - Physics Option 3

Queries the Academic Plan Review (**APR**) Module of People Soft

1

Student logs-in

### Select one of your unmet General Requirements

Technical GPA

LIMIT - No Preqs Allowed

Second-Level Reading and Composition

Business Principles

Technical Courses P/NP Limit

Economics

Statistics

Other General Requirements (completed or unavailable)

### Or select one of your unmet Electrical Eng & Computer Sci Requirements

Ethics

Physics Option 3

Physics Option 4

Physics Option 5

Other Electrical Eng & Computer Sci Requirements (completed or unavailable)

☐ Only Show Courses with Open Seats

Considerations for Fall 19:

CCN	Class	Subject
19319	Social Implications of Computer Technology (195)	Computer Science
29166	Energy and Society (C100)	Energy and Resources
27356	Ethics in Science and Engineering (100)	Bioengineering

3

Is shown courses satisfying that requirement available in the next semester

2

Selects one of her remaining requirements

Enterprise Data Warehouse

Enrollment data

Office of the Registrar

Student APR data



Office of the Registrar

Course catalog descriptions  
(via Course API)



Explore  
Courses

*“We want students to find their own path, not follow others”*

- UC Berkeley Staff

*“Will a recommender system only show the popular courses?”*

- UC Berkeley Student

# Generate serendipitous course suggestions

## Choose a Favorite Course

Subject

Sociology

×

Course

Evaluation of Evidence (5)

×

Search

## Considerations across campus

### #1 [Data Science Connector](#)

Letters & Science (88)

Connector courses are intended to connect the Foundations of Data Science (COMPSCI C8/INFO C8/STAT C8) course with particular fields of study. They will apply the concepts and techniques of the foundation course to topics of interest in a particular discipline in order for students to develop critical thinking in data in subject areas that most interest them; these courses also provide a more nuanced understanding of the context in which the data comes into existence.

### #2 [Introduction to Urban Data Analytics](#)

City & Regional Planning (101)

This course (1) provides a basic intro to census and economic data collection, processing, and analysis; (2) surveys forecasting and modeling techniques in planning; (3) demonstrates the uses of real-time urban data and analytics; and (4) provides a socio-economic-political context for the smart cities movement, focusing on data ethics and governance.

### #3 [Introduction to Ecological Data Analysis](#)

Env Sci, Policy, & Mgmt (173)

Introduces concepts and methods for practical analysis of data from ecology and related disciplines. Topics include data summaries, distributions, and probability; comparison of data groups using t-tests and analysis of variance; comparison of multi-factor groups using analysis of variance; evaluation of continuous relationships between variables using regression and correlation; and a glimpse at more advanced topics. In computer laboratories, students put concepts into practice and interpret results.

### #4 [Cartographic Representation](#)

Geography (183)

Problems in the representation of quantitative and qualitative data on thematic maps.

[1] Student selects a favorite course (relevance signal)

[2] Generate results based on similarity to the favorite course in our model. Diversify by Department

# How is *Serendipity* defined?

***Unexpectedness + Successfulness***

(Shani & Gunawardana, 2011)



***Diversity***

Mechanism frequently used  
to produce unexpectedness

- Choose items from across several appropriate categories (domain specific)
- Often used in combination with a signal of user relevance (content/collaborative-based)



- Has been the primary optimized outcome in recommender systems (e.g., CTR, consuming, buying, following)



***Filter Bubble***

Over personalized/Overfit/Narrowing  
model of user interest  
(Kay, 2000; Nguyen, 2014)



# Online Validation: User Study

- **70** UC Berkeley students from across campus participated
- Each student specified **a favorite course** they had taken at the university
- 10 course recommendations were generated from our candidate serendipity-designed ML models and from the session-based RNN

# Online Validation: User Study

- For each course recommended, they rated their level of agreement with the following **3** statements:
  - “This course was unexpected” [unexpectedness]
  - “I am interested in taking this course” [successfulness]
  - “I did not know about this course before” [novelty]
- Students also rated the 10 recommendations from an algorithm as a whole, with agreement to the following:
  - “Overall, the course results were diverse” [diversity]
  - “The course results shared something in common with my favorite course” [commonality]

# Online Validation: User Study Results

Average user ratings of courses based on five measures

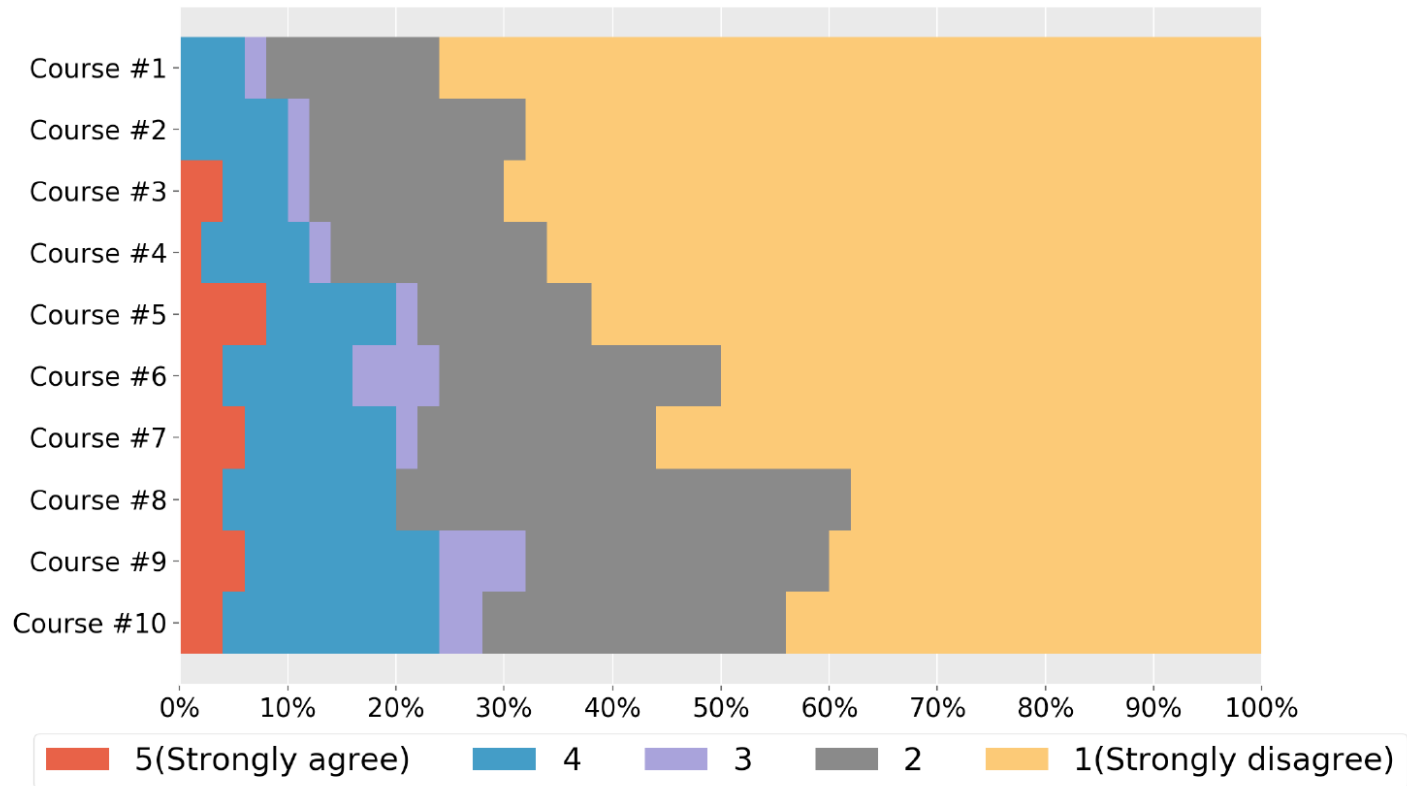
representation	unexpected	successful	serendipity	novelty	diversity	commonality
Catalog Descrip.	<b>3.550</b>	2.904	<b>3.227</b>	<b>3.896</b>	4.229	3.229
tfidf & multi-c2v (div)	3.473	2.851	3.162	3.310	<b>4.286</b>	2.986
bin. & multi-c2v (div)	3.297	2.999	3.148	3.323	4.214	3.257
bin. & multi-c2v (non-div)	2.091	<b>3.619</b>	2.855	2.559	2.457	<b>4.500</b>
Collaborative	2.184	3.566	2.875	<b>1.824</b>	3.160	4.140

(serendipity is the average of unexpected and successful)

Pardos, Z.A., Jiang, W. (In press) Designing for Serendipity in a University Course Recommendation System. In K. Verbert, M. Scheffel, N. Pinkwart, & V. Kovanovic (Eds.) *Proceedings of the 10th International Conference on Learning Analytics and Knowledge (LAK 2020)*. ACM. Frankfurt, Germany.

# Lack of novelty in “people like you took X” style recommendation in user test

“I did not know about this course before”



AskOski Explore Requirements SearchQ Contact CalNet Login

## Course Exploration

Continue your intellectual journey. Explore considerations based on a favorite course you have taken

Enter a subject and course and AskOski will suggest related courses:

### Choose a Favorite Course

Subject:  Course:   ☐ Include Graduate Courses

### Considerations across campus

**#1 Data Science Connector**  
Letters & Science (88)

Connector courses are intended to connect the Foundations of Data Science (COMPSCI C8/INFO C8/STAT C8) course with particular fields of study. They will apply the concepts and techniques of the Foundation course to topics of interest in a particular discipline in order for students to develop critical thinking in data in subject areas that most interest them; these courses also provide a more nuanced understanding of the context in which the data comes into existence.

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**#4 Cartographic Representation**  
Geography (183)

Problems in the representation of quantitative and qualitative data on thematic maps.

**#5 The Person in Big Data**  
Psychology (7)

This course will introduce students to the basic principles and methods of personality and social psychology as applied to a rapidly growing topic of modern society—the collection and analysis of online social “big data.” Students will learn about the ways in which big data has historically been defined, collected, and utilized, as well as fundamental concepts in person perception and social behavior that are relevant to topics of big data collection, analysis, and interpretation.

### Matches within Sociology

**#1 The Power of Numbers: Quantitative Data in Social Sciences**  
Sociology (7)

This course will provide students with a set of skills to understand, evaluate, use, and produce quantitative data about the social world. It is intended specifically for social science majors, and focuses on social science questions. Students will learn to: produce basic graphs, find good-quality and relevant data on the web, manipulate data in a spreadsheet, including producing pivot tables, understand and calculate basic statistical measures of central tendency, variation, and correlation, understand and apply basic concepts of sampling and selection, and recognize an impossible statistic.

**#2 Research Design and Sociological Methods**  
Sociology (105)

## System Implementation

BOW (div) now generates the “across campus” results

- best serendipitous rated model

Binary BOW + multi-c2v now generates the within department results

- best equivalency model

Enterprise Data Warehouse

Enrollment data

Berkeley Academic Guide

Office of the Registrar

Course catalog descriptions  
(via Course API)



SearchQ

## Infer latent topics of courses

Course description may not be informative

**2019 Fall** LATIN 1 001 - LEC 001 offered through Classics

### Elementary Latin

Emily Mullin

M, TU, W, TH

Class #: 22195

10:00 am - 10:59 am

Units: 4

Dwinelle 106



#### Open Seats

9 Seats Reserved for Students with Enrollment Permission

Beginners' course.

Course description may contain unfamiliar jargon

**2019 Fall** EDUC C260F 001 - LEC 001 offered through Graduate School of Education

### Machine Learning in Education

Class #: 33193

Units: 3



#### Open Seats

6 Unreserved Seats

This course covers computational approaches to the task of modeling learning and improving outcomes in Intelligent Tutoring Systems (ITS) and Massive Open Online Courses (MOOCs). We will cover theories and methodologies underpinning current approaches to knowledge discovery and data mining in education and survey the latest developments in the broad field of human learning research....

Students are not experts. Their queries will reflect basic pre-conceptions



## Infer latent topics of courses

Course description may not be informative

**2019 Fall** LATIN 1 001 - LEC 001 offered through Classics

### Elementary Latin

Emily Mullin

M, TU, W, TH

Class #: 22195

10:00 am - 10:59 am

Units: 4

Dwinelle 106

#### Open Seats

9 Seats Reserved for Students with Enrollment Permission

Beginners' course.



Inferred Keywords: prose, poetry, grammar, medieval, greek

Course description may contain unfamiliar jargon

**2019 Fall** EDUC C260F 001 - LEC 001 offered through Graduate School of Education

### Machine Learning in Education

Class #: 33193

Units: 3

#### Open Seats

6 Unreserved Seats

This course covers computational approaches to the task of modeling learning and improving outcomes in Intelligent Tutoring Systems (ITS) and Massive Open Online Courses (MOOCs). We will cover theories and methodologies underpinning current approaches to knowledge discovery and data mining in education and survey the latest developments in the broad field of human learning research....



Inferred Keywords: algorithms, covers, computational, cover, modeling, discussions, communication, implementation

Dong, M., Yu, R., Pardos, Z.A. (2019) Design and Deployment of a Better Course Search Tool: Inferring latent keywords from enrollment networks. In M. Scheffel & J. Broisin (Eds.) *Proceedings of the 14<sup>th</sup> European Conference on Technology Enhanced Learning (EC-TEL)*. Delft, The Netherlands. Springer. Pages 480-494.

# Online Validation: User Study

- **75** UC Berkeley students from across campus participated
- Each student specified **6 favorite courses** they had taken at the university
- For each course, keywords from the translation model and other baselines were displayed in random order
- Students rated each keyword on a five point Likert scale

Which method produces the most relevant course keywords as judged by students who took the course?

How relevant are the keywords to the course as compared to words from the actual description?

# Online Validation: User Study

[AskOski](#)[Explore](#)[Requirements](#)[Search Study](#)[Contact](#)[Welcome STUDENT](#)[Logout](#)

## Search Study

Step 2: Rate each keyword's relevance to the course content based on the following scale:

(Keywords may or may not be relevant)

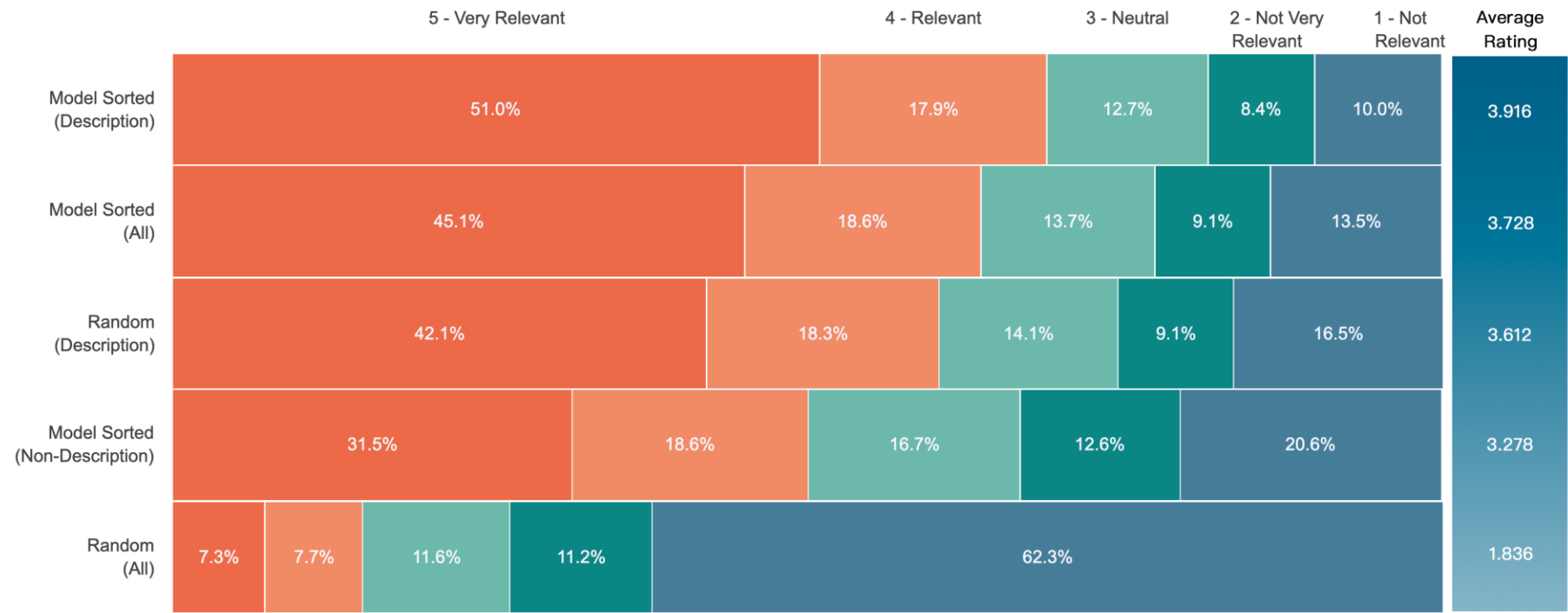
1	2	3	4	5
Not At All Relevant	Not Very Relevant	Neutral	Somewhat Relevant	Very Relevant

### Statistics 135: Concepts of Statistics

(You took this course during Spring 2017 with )

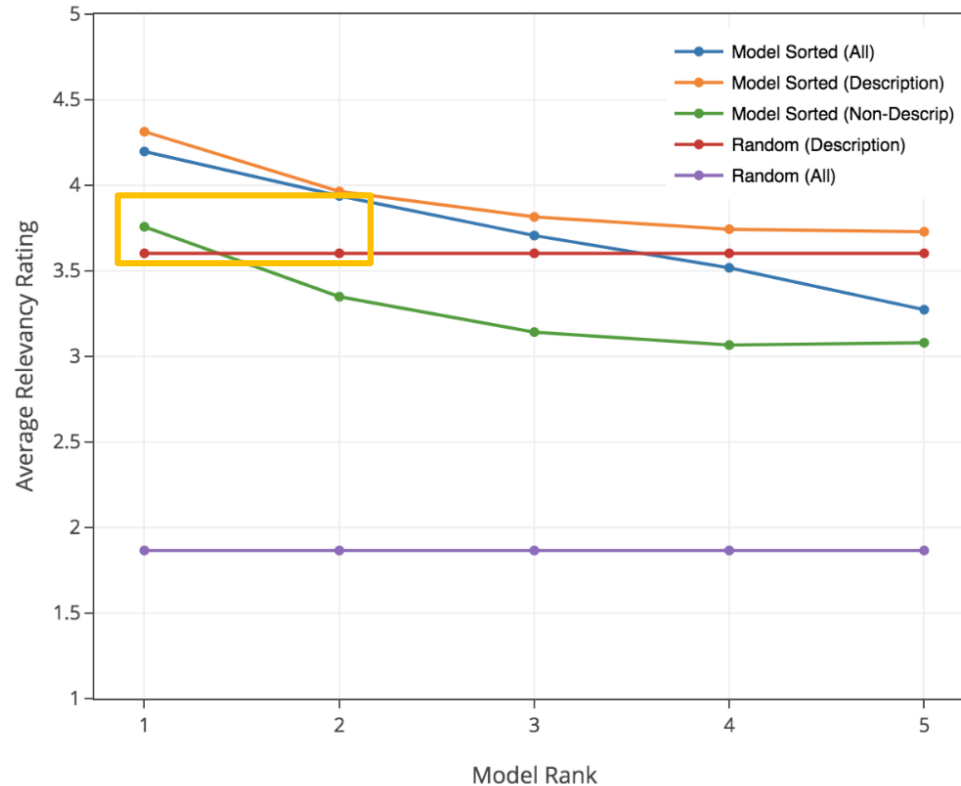
	Keyword	Relevance
#1	methods	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input checked="" type="radio"/> 4 <input type="radio"/> 5
#2	statistics	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input checked="" type="radio"/> 5
#3	real	<input type="radio"/> 1 <input type="radio"/> 2 <input checked="" type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5
#4	user interfaces	<input type="radio"/> 1 <input type="radio"/> 2 <input checked="" type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5
#5	variance	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input checked="" type="radio"/> 4 <input type="radio"/> 5
#6	course	<input type="radio"/> 1 <input type="radio"/> 2 <input checked="" type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5
#7	topics problems	<input type="radio"/> 1 <input type="radio"/> 2 <input checked="" type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5
#8	statistical	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input checked="" type="radio"/> 5
#9	regression	<input type="radio"/> 1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input checked="" type="radio"/> 5

# Online Validation Results



# Online Validation Results

Rank versus Relevancy



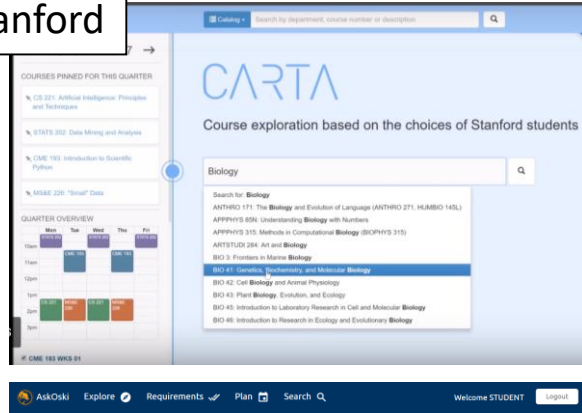
Correlation between probability and rank was used to select a threshold of probability from Model Sorted (All) group, such that all keywords above that probability can be expected to be more relevant, on average, than a word chosen at random from the description.



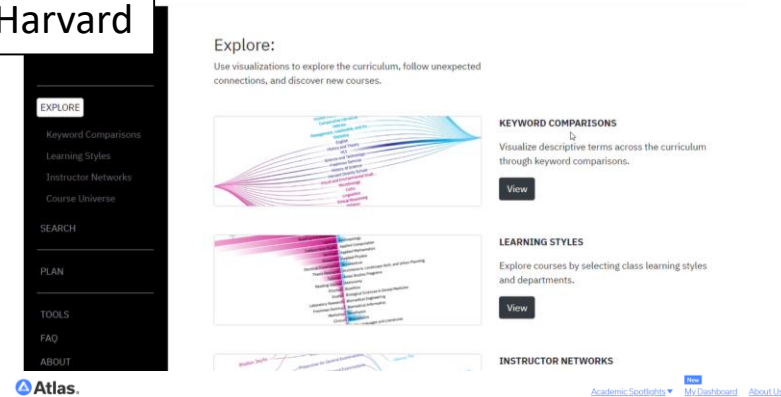
(Instructor results preview)

# Nascent Course Information Platforms

Stanford



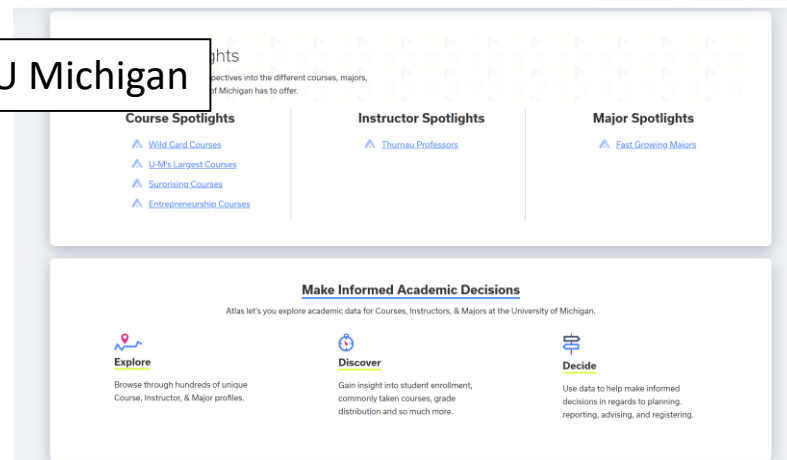
Harvard



UC Berkeley



U Michigan



# DISCUSSION

- Give students the data you want them to make decisions based on
- More Information is not always better

(Do not show students grade distributions)

Chaturapruek, S., Dee, T. S., Johari, R., Kizilcec, R. F., & Stevens, M. L. (2018, June). **How a data-driven course planning tool affects college students' GPA: evidence from two field experiments.** In *Proceedings of the Fifth Annual ACM Conference on Learning at Scale* (pp. 1-10).



# My Future Directions

- Within UC Berkeley
- Outside of UC Berkeley

# References

- Pardos, Z.A., Jiang, W. (In press) Designing for Serendipity in a University Course Recommendation System. In K. Verbert, M. Scheffel, N. Pinkwart, & V. Kovanovic (Eds.) *Proceedings of the 10th International Conference on Learning Analytics and Knowledge* (LAK 2020). ACM. Frankfurt, Germany.
- Dong, M., Yu, R., Pardos, Z.A. (2019) Design and Deployment of a Better Course Search Tool: Inferring latent keywords from enrollment networks. In M. Scheffel & J. Broisin (Eds.) *Proceedings of the 14<sup>th</sup> European Conference on Technology Enhanced Learning* (EC-TEL). Delft, The Netherlands. Springer. Pages 480-494.
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- Jiang, W., Pardos, Z.A. (2019) Time Slice Imputation for Personalized Goal-based Recommendation in Higher Education. In D. Tikk & P. Brusilovsky (Eds.) *Proceedings of the 13th ACM Conference on Recommender Systems*. Copenhagen, Denmark. ACM. Pages 506-510.
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# The Data and Algorithms that Power AskOski


## Thank You!


Thank You!

Questions?


Zachary A. Pardos  
*University of California at Berkeley*




AskOski: A Personalized Course Information Platform

CalNet Login

Explore personalized course information based on historic enrollments

Explore

AskOski (<https://askoski.berkeley.edu>) draws together information distributed throughout the University into a central platform allowing students to illuminate their academic terrain like never before. The system incorporates degree audit, course description, and historic enrollment information combined with machine learning to help students explore their interests, connecting course concepts across departments, while satisfying complex constraints of their programs.

Big Data

The project is an effort started in the summer of 2016, supported by NSF EAGER awards (#1547055 and 1446641), developed in close collaboration with the Office of the Registrar, IS&T, and the Office of Planning and Analysis. It has made higher education a first-class beneficiary of the latest techniques in AI and natural language processing and catalyzed conversations on the role of big data and learning analytics on campus. The system is in continual development, grappling with aiding students in achieving their personal goals while retaining the values and pedagogical objectives of the institution.

In addition to forwarding the educational mission of the

Project lead:

Zachary Pardos <[zpardos@berkeley.edu](mailto:zpardos@berkeley.edu)>  
Assistant Professor  
University of California at Berkeley  
Graduate School of Education (50%)  
School of Information (50%)

Project Team:

Christopher Le (EECS Undergraduate)  
Zhao Fan (School Master's)  
Arshad Ali (EECS Undergraduate)  
Alessandra Silveira (GSE Master's)  
Andrew Nam (ECON/EECS undergraduate)  
Mark Chiang (IST - Data Warehouse)  
Max Michel (IST - Data Warehouse)  
Aswan Movva (IST - Data Warehouse)  
Anj Gannavarapu (IST - Data Warehouse)  
Daniel Grieb (IST - Data Warehouse)  
Andrew Eppig (Office of Planning and Analysis)

One-page recommender system synopsis: [tiny.cc/askoski](https://tiny.cc/askoski)

Acknowledgement: This work was funded by the National Science Foundation  
(Awards #1547055, #1446641)