



# Knowledge Spaces as Networks

David Stelter  
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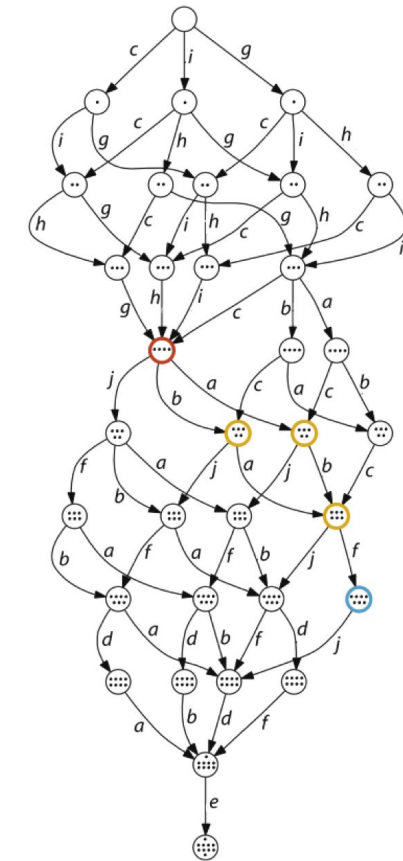


# Knowledge Space Theory



# Definitions

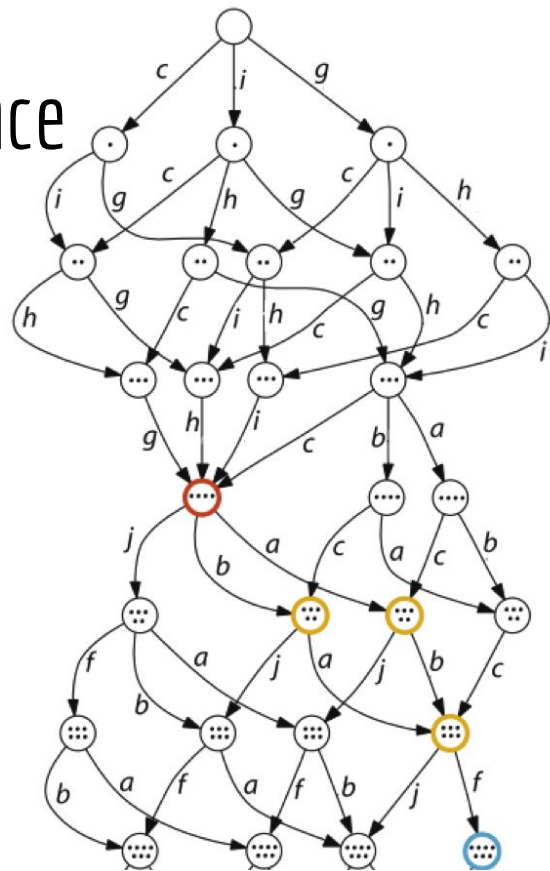
- **item** - a specific topic or skill
- **domain** - a related set of items, typically for a given field or class
- **knowledge state** - a set of items that constitutes a possible set of things a person could know
- **knowledge space** - the set of all possible knowledge states over a domain
- **fringe** - the set of knowledge states one item away from a certain state
- The field was pioneered by Jean-Paul Doignon and Jean-Claude Falmagne at Université Libre de Bruxelles and UC Irvine, respectively



Falmagne, J.-C.; Albert, D.; Doble, C.; Eppstein, D.; Hu, X.  
*Knowledge Spaces: Applications in Education*; 2013.

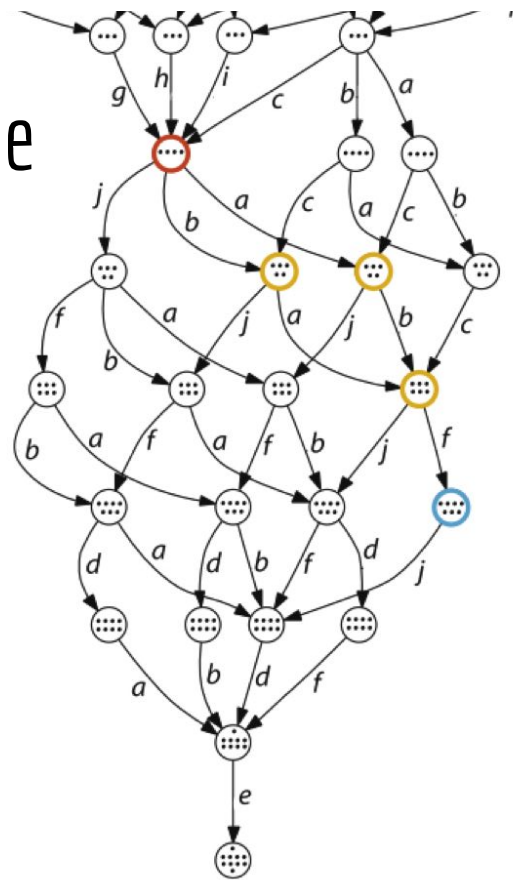
# Small Sample Knowledge Space

- A. Quotients of expressions involving exponents
- B. Multiplying two binomials
- C. Plotting a point on the coordinate plane
- D. Writing the equation of a line given a point and the slope
- E. Solving a word problem using a set of linear equations
- F. Graphing a line given its equation
- G. Multiplication of a decimal by a whole number
- H. Integer addition
- I. Equivalent fractions
- J. Graphing integer functions



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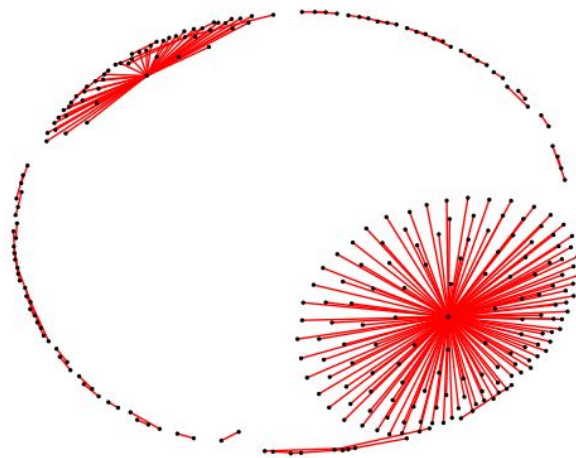
# Our Studied System

- **domain** - 571 items for a general chemistry class
  - maximum possible set of knowledge states is  $2^{571} = 8 \times 10^{171}$
- knowledge states from Assessment and Learning in Knowledge Space (ALEKS), an adaptive online instruction tool
  - largely NSF funded
  - they care about their intellectual property
- we got a sample of knowledge states of BU students over the past four years



# Network Structure

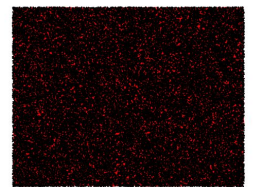
# Single Class Visualization



Total Edges = 36162

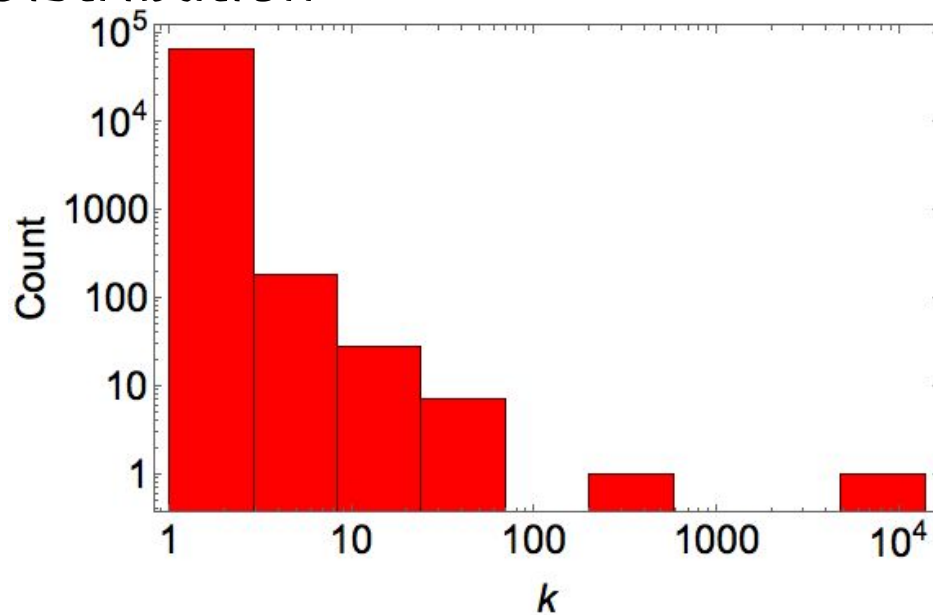
Total Unique Learning States = 64444

$\langle k \rangle = 1.1223$

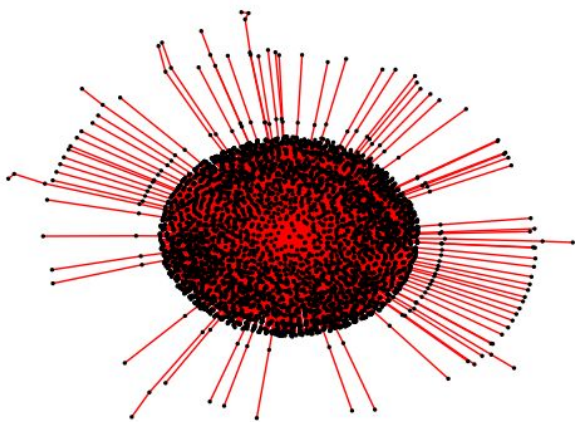




# Degree Distribution

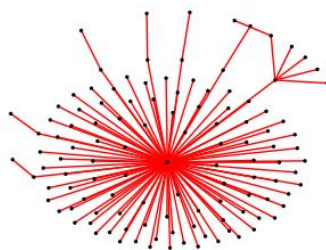


# Largest Component

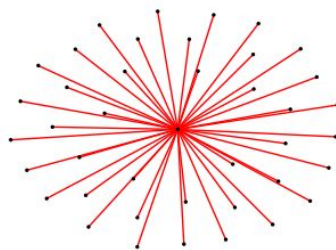
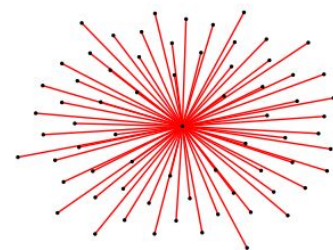


5819 nodes, diameter = 9

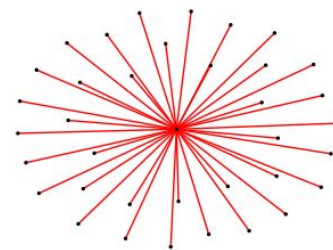
# Second Largest



# Third Largest

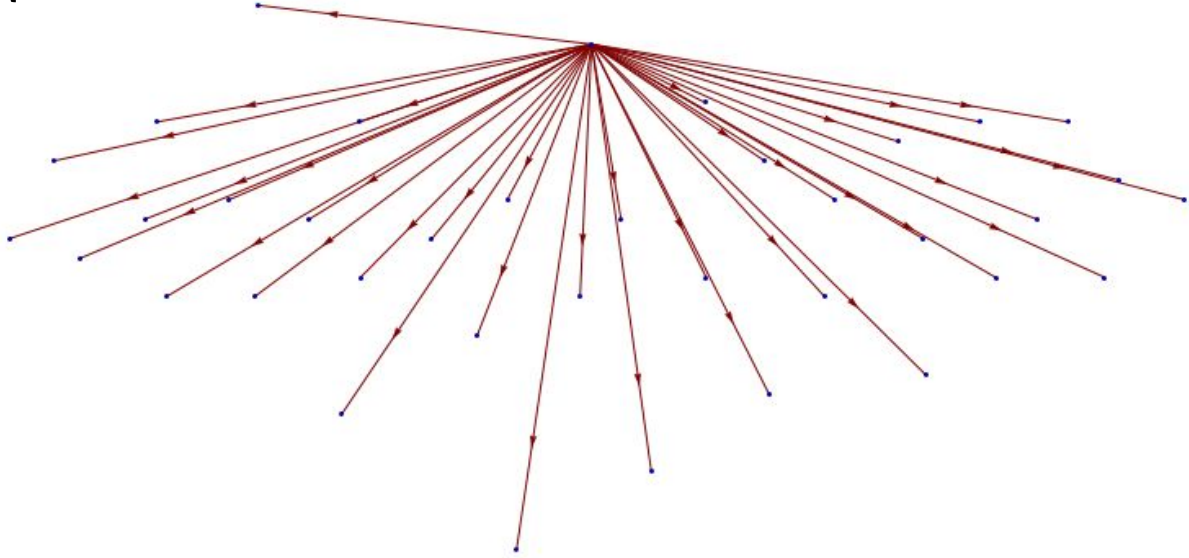


# Fourth Largest

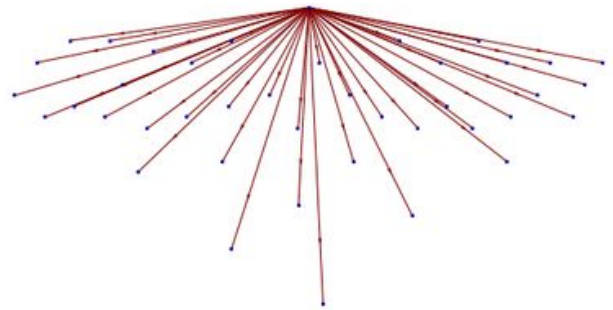
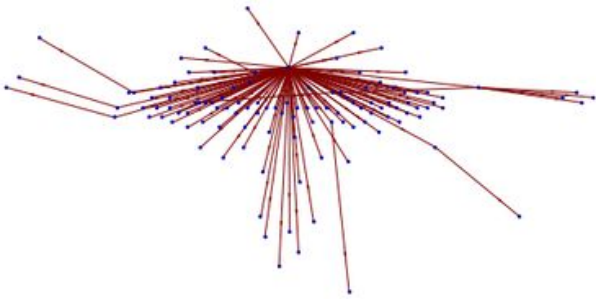


# Fifth Largest

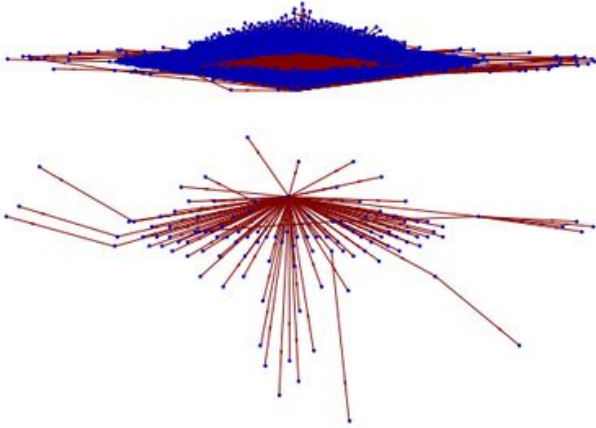
# Components (Item Counts)



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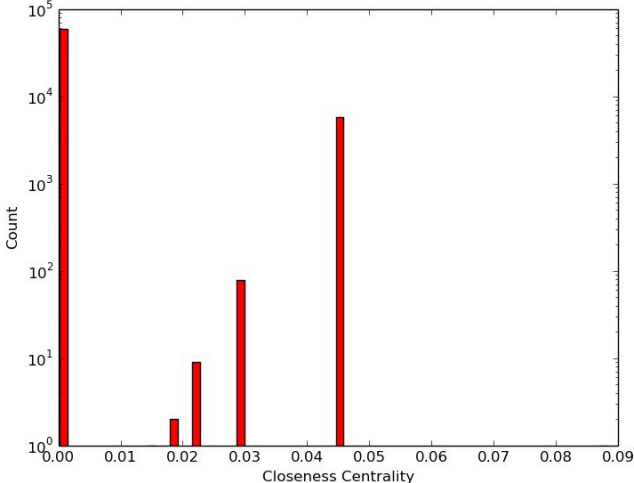
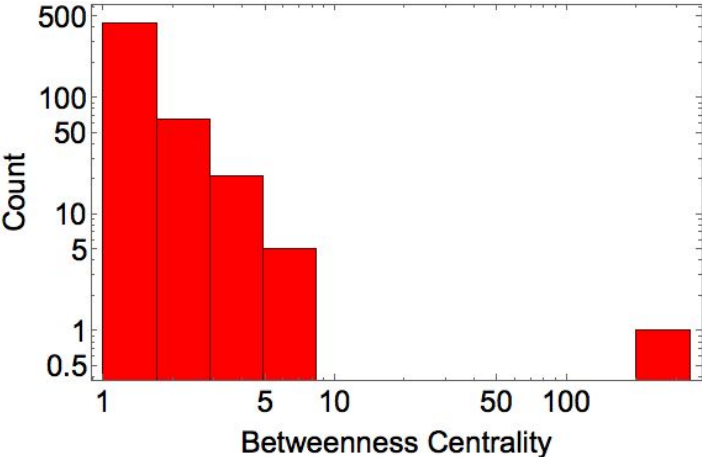


# Components (Item Counts)



	$\mu$	$\sigma$	N
1	80.533	36.49	5819
2	134.	8.936	117
3	97.652	8.588	69
4	114.878	5.515	41
5	102.081	5.761	37
6	202.6	6.055	30
7	173.536	7.037	28
8	116.44	5.181	25
9	85.56	5.874	25
10	260.542	10.746	24
11	123.042	8.745	24
12	98.636	9.137	22
13	186.	8.159	22
14	138.	5.532	21
15	101.6	8.165	20
16	132.65	4.03	20
17	209.526	4.683	19
18	143.667	6.259	18
19	236.611	3.696	18
20	76.444	4.301	18

# Centralities



# Future Work

Understand structure of large components and meaning of the central node.

Identify states crucial to student learning

Add assessments to get a finer progression of student learning progress to increase overall network connectivity

Propose analysis to possibly be run on the full network

Obtain full subset of the knowledge space to analyze

Add weights by assessing time spent between knowledge states



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