



Analyzing Learning and Teaching through the Lens of Networks

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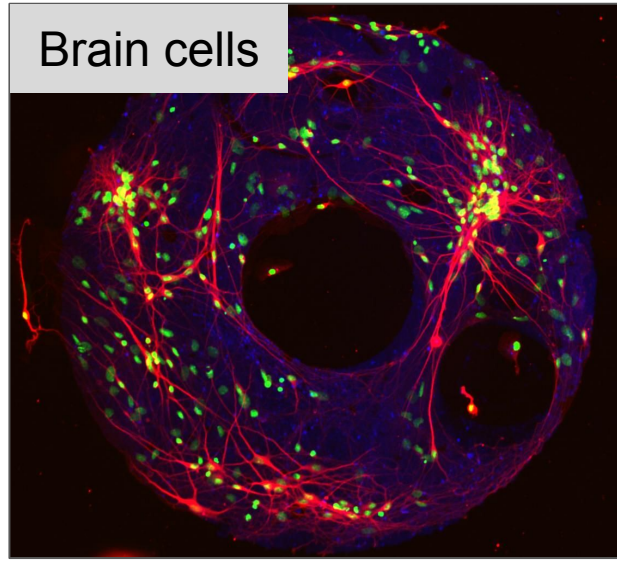
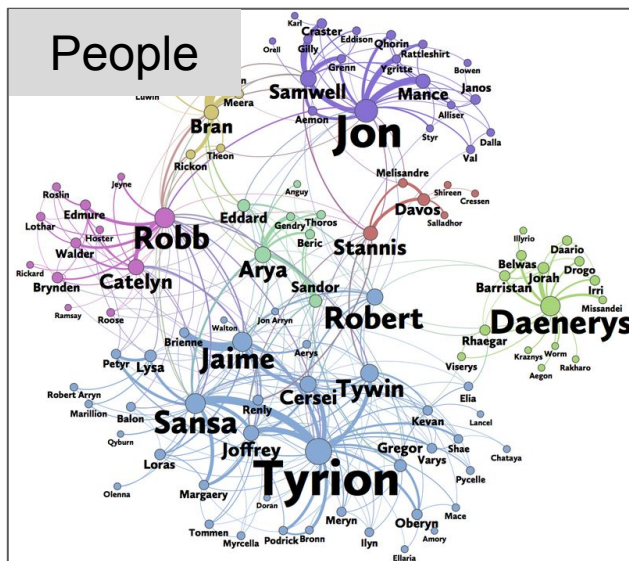
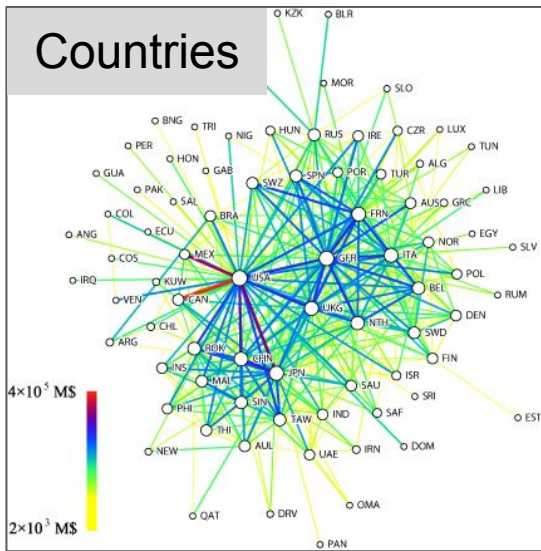
Acknowledgement

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Agenda

- Introduction: The network worldview
- Applied network analysis
 - Four core messages
- Applying network analytics in teaching
- Q&A

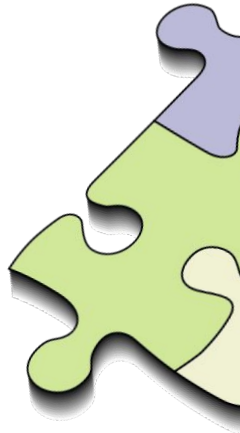
Networks are everywhere!



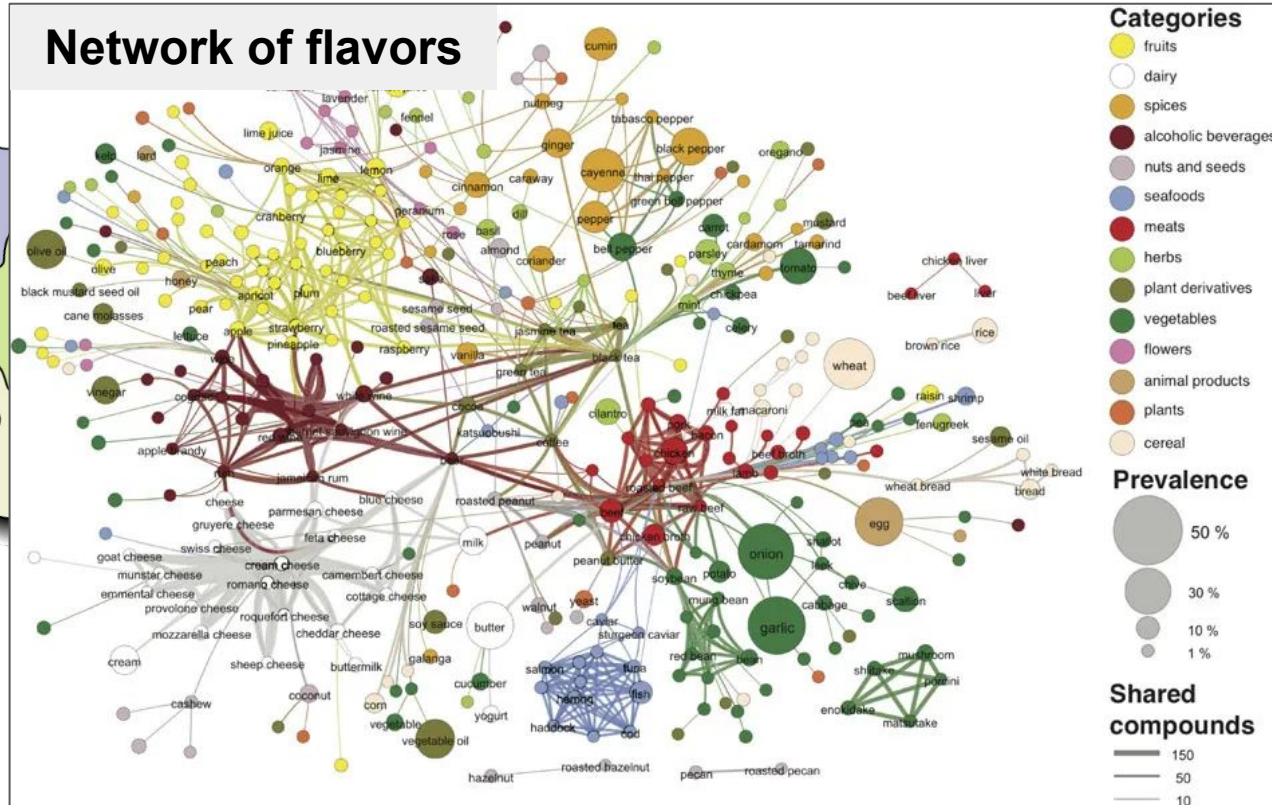
(Photo Credits: [1](#), [2](#), [3](#), [4](#))

Why networks?

Representational



Network of flavors

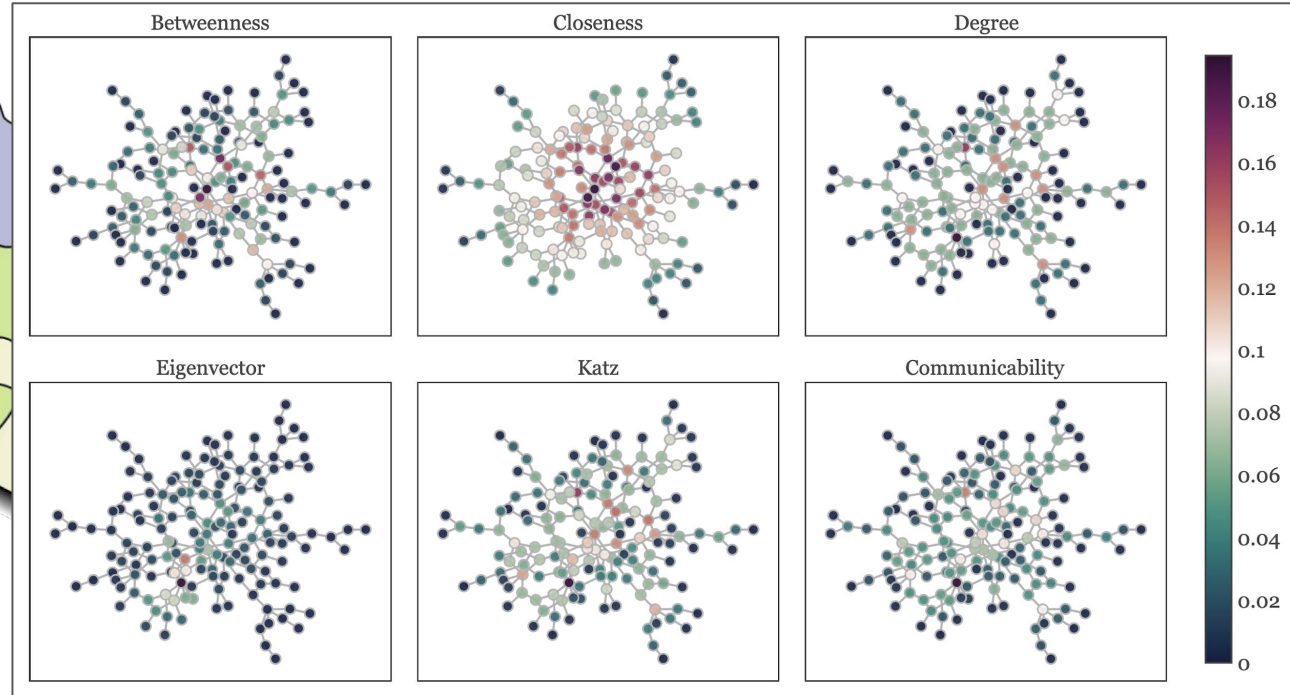
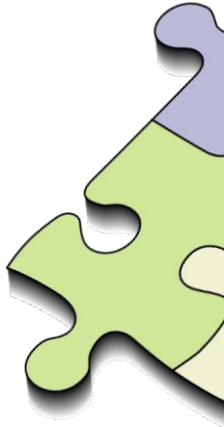


(Ahn et al., 2011; [Photo Credit](#))

Why networks?

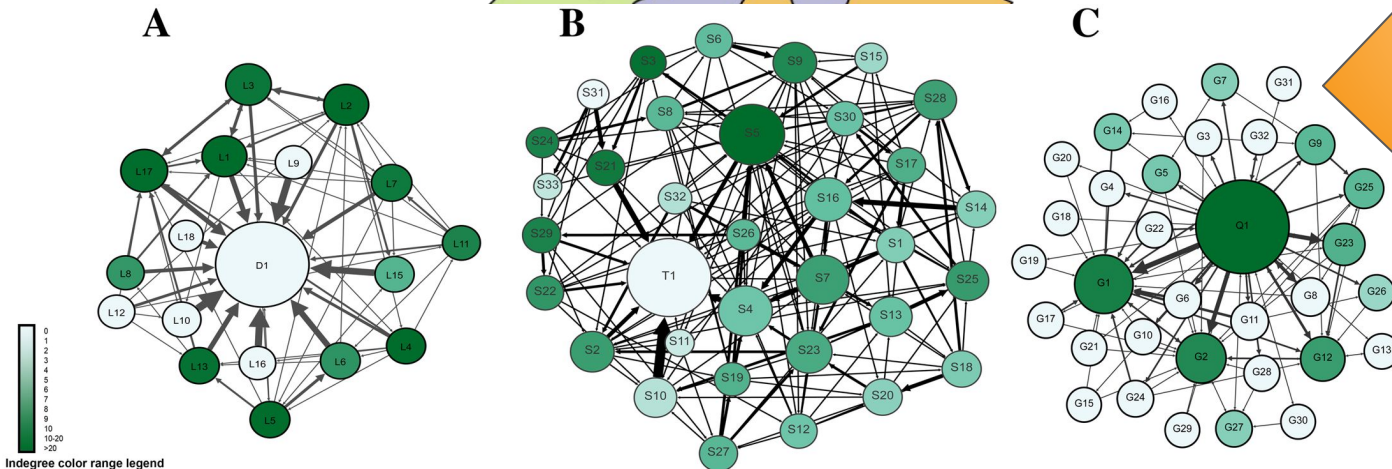
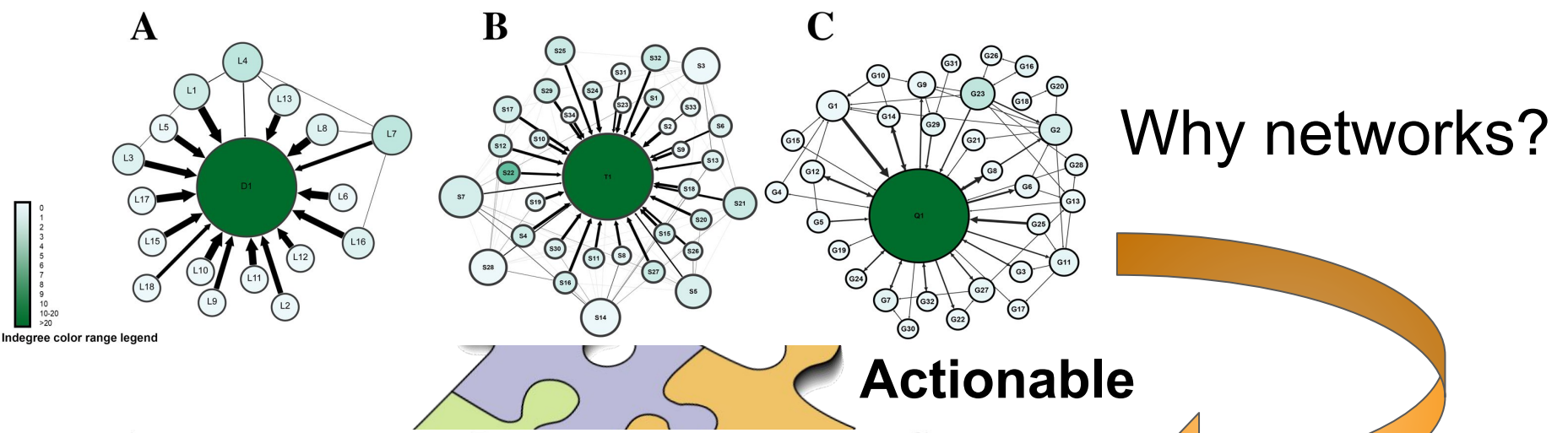
Representational

Analytical

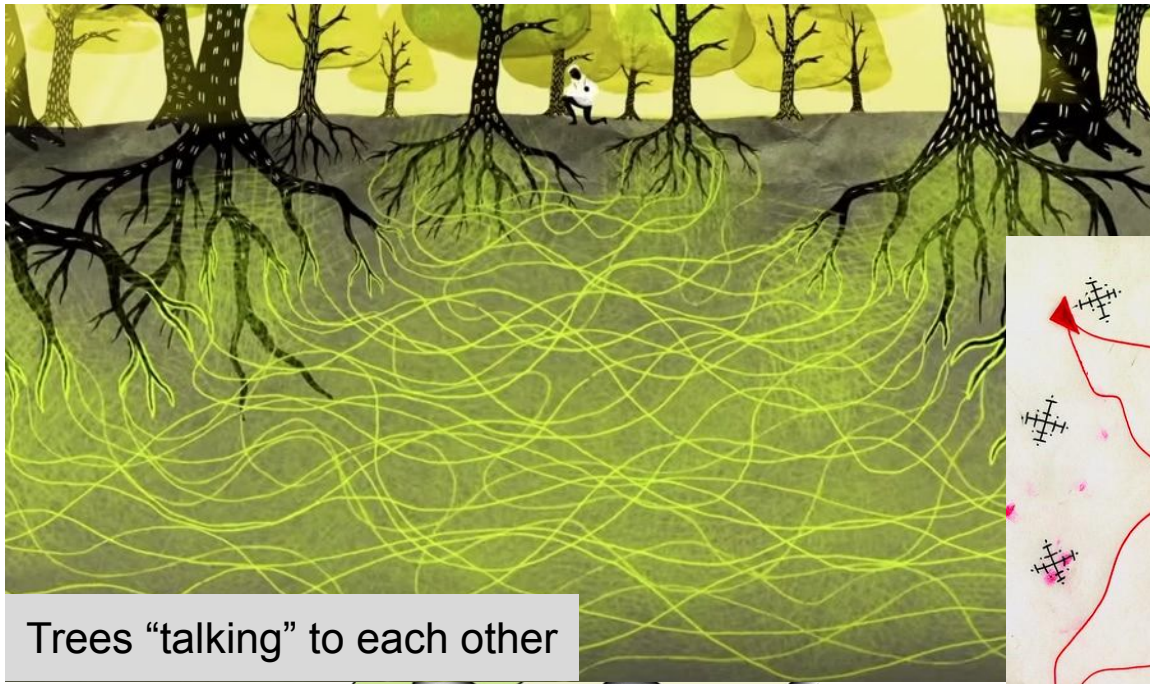


Network centrality measures

([Photo Credit](#))

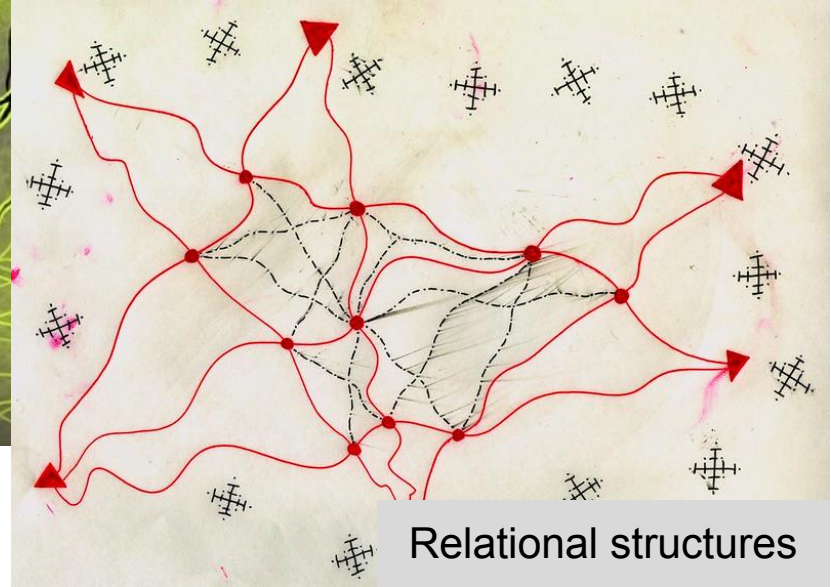


Saqr, M., Fors, U., Tedre, M., & Nouri, J. (2018). How social network analysis can be used to monitor online collaborative learning and guide an informed intervention. *PLOS ONE*, 13(3), e0194777. <https://doi.org/10.1371/journal.pone.0194777>



Trees “talking” to each other

Why networks?

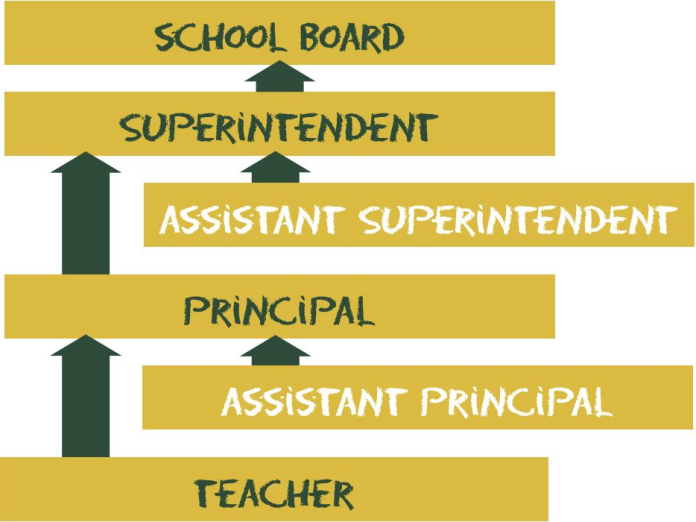


Relational structures

Epistemological

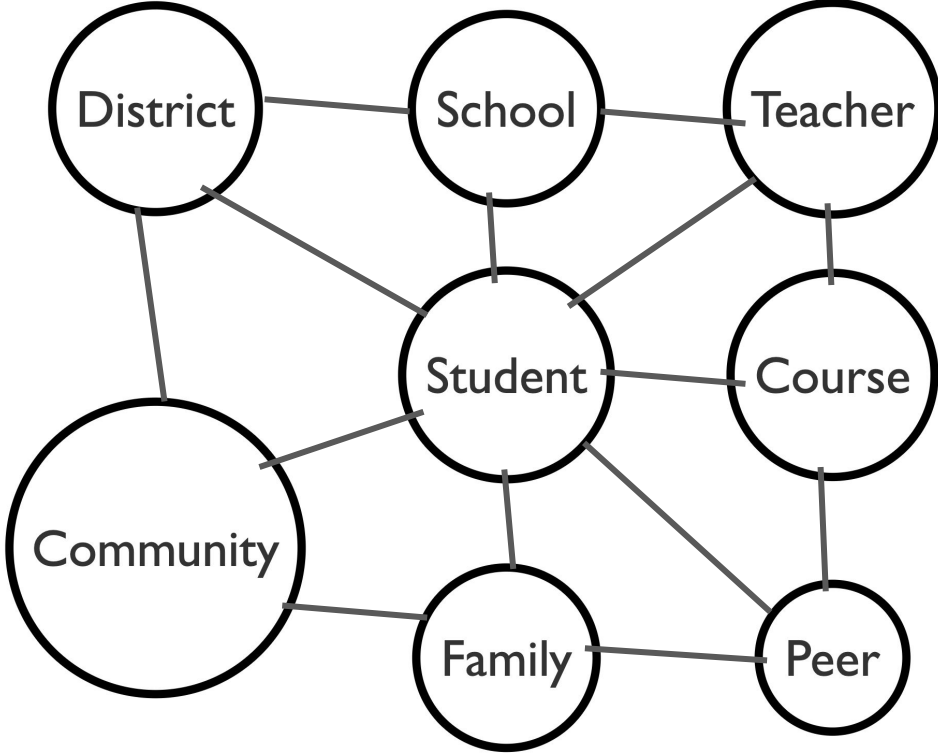
(Singh, 2019)

Networks in Education



Hierarchical

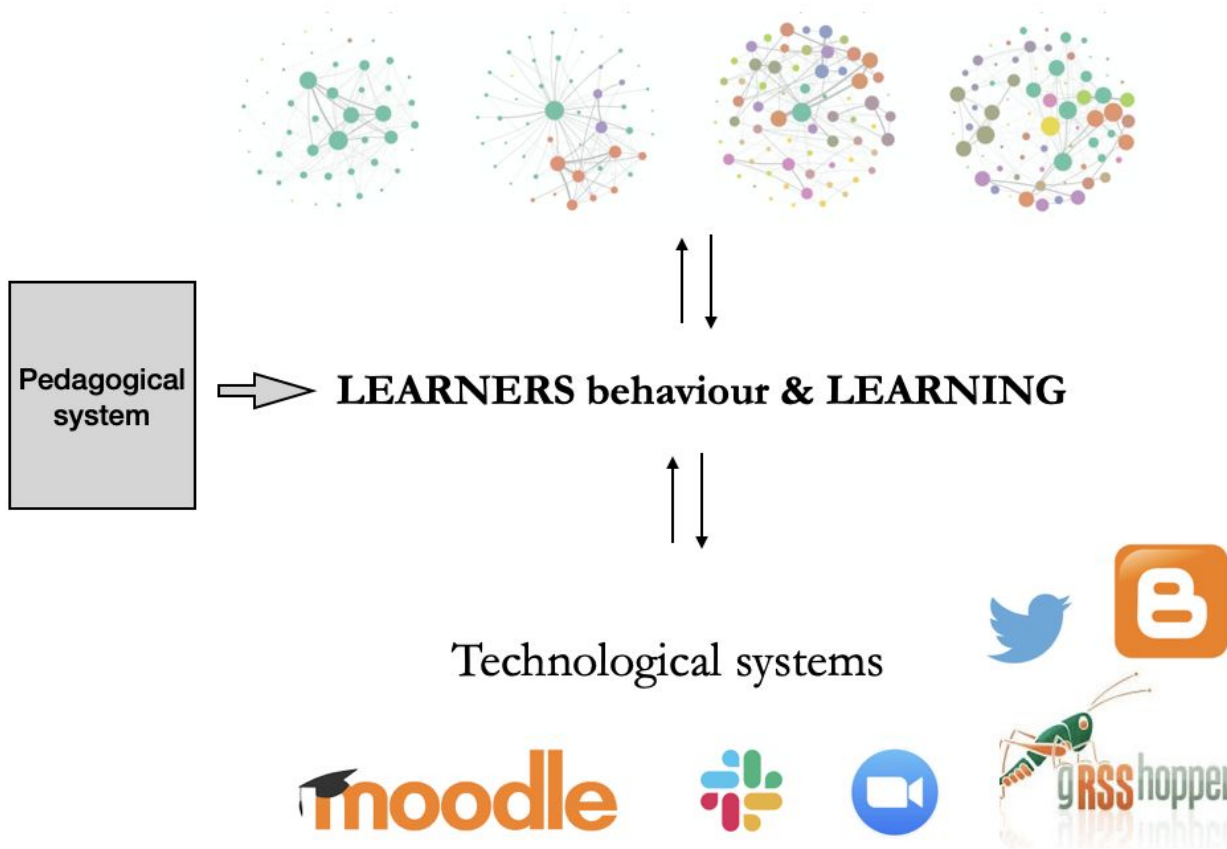
[\(Photo Credit\)](#)



Complex

Socio-technical systems

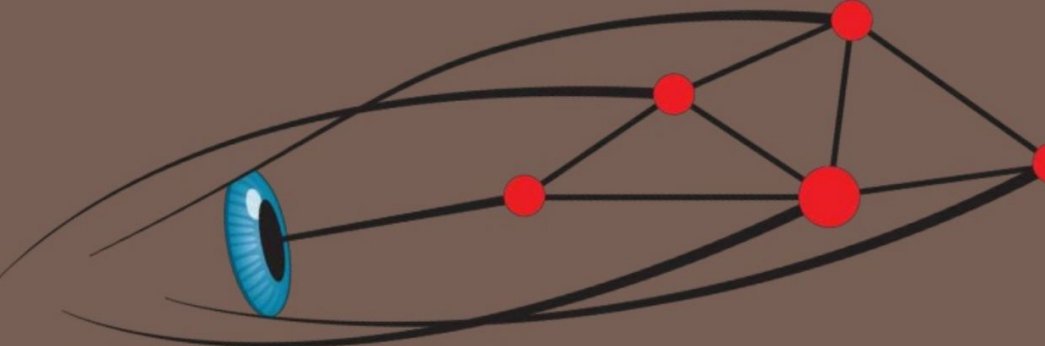
Social systems



How network analysis can be helpful for understanding learning?

Not new: LAK'11 and pre-LAK

SNAPP: A BIRD'S-EYE VIEW OF TEMPORAL PARTICIPANT INTERACTION



Ms Aneesha Bakharia,
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Learning Analytics & Knowledge 2011

Applied Network Analysis: Core Messages



- **Networks are much more than social networks**

Applied Network Analysis: Core Messages



- **Networks are much more than social networks**
- **Not all centralities measures are made equal**

Applied Network Analysis: Core Messages



- **Networks are much more than social networks**
- **Not all centralities measures are made equal**
- **Network models matter**

Applied Network Analysis: Core Messages



- **Networks are much more than social networks**
- **Not all centralities measures are made equal**
- **Network models matter**
- **Network evaluation is subjective and multi-dimensional**



Networks are more than social networks

Graphs are often used as a method
to reduce high-dimensional data.

Here: networks = graphs = diverse entities and relations



Networks are more than social networks

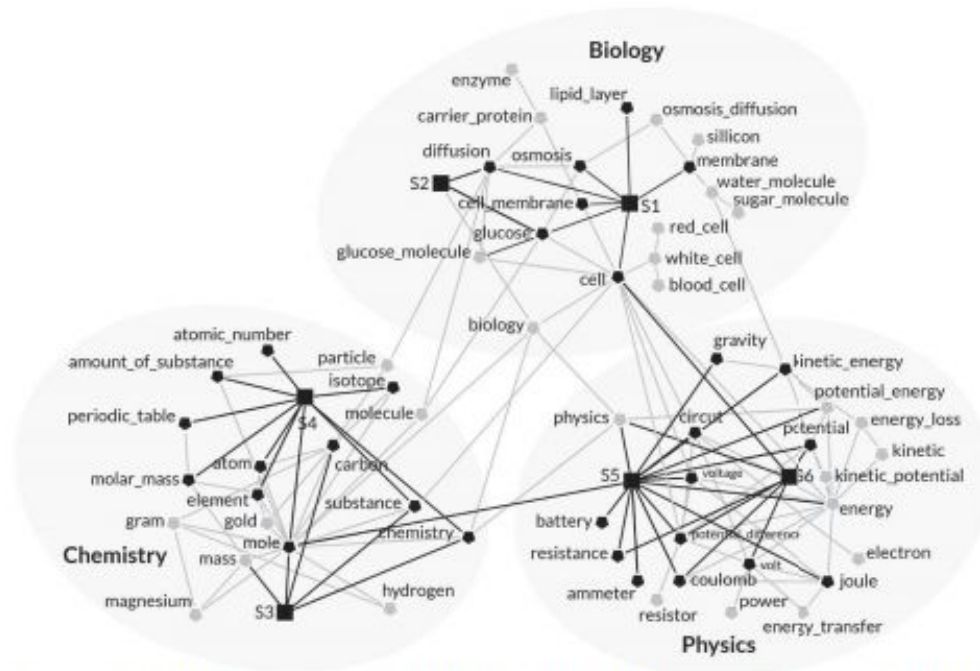
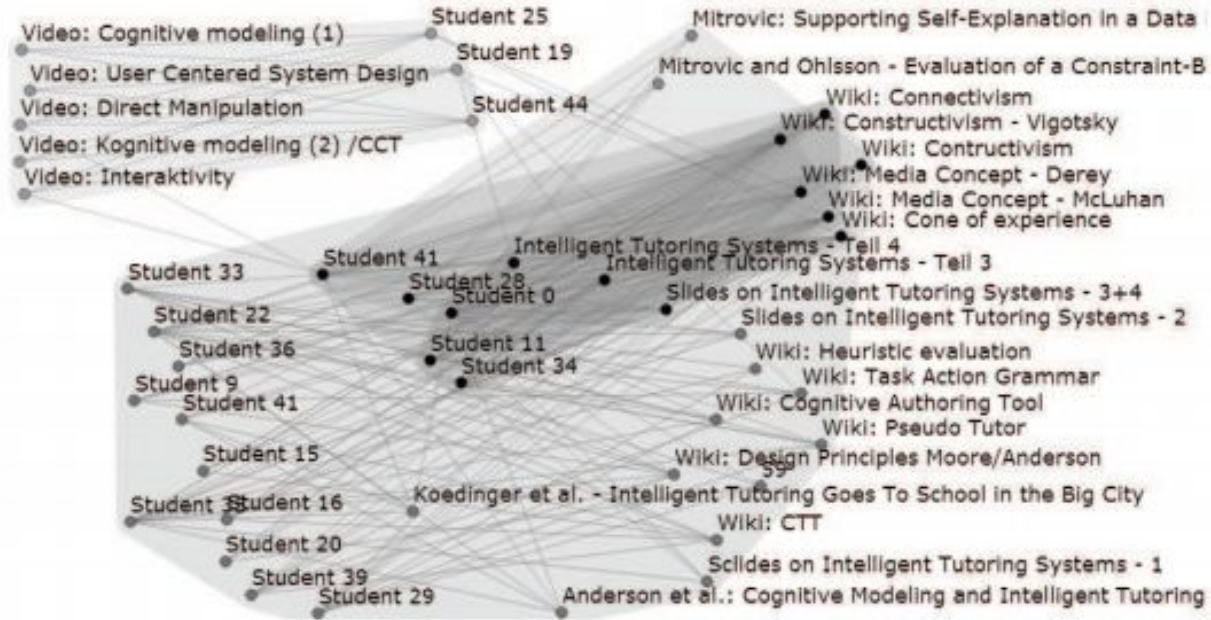


Figure 2.1. Topic–topic and person–topic relations extracted from transcripts of teacher–student workshops.



Networks are more than social networks



Hoppe, H. U. (2017). Computational methods for the analysis of learning and knowledge building communities. *The Handbook of learning analytics*, 23-33.



Networks are more than social networks

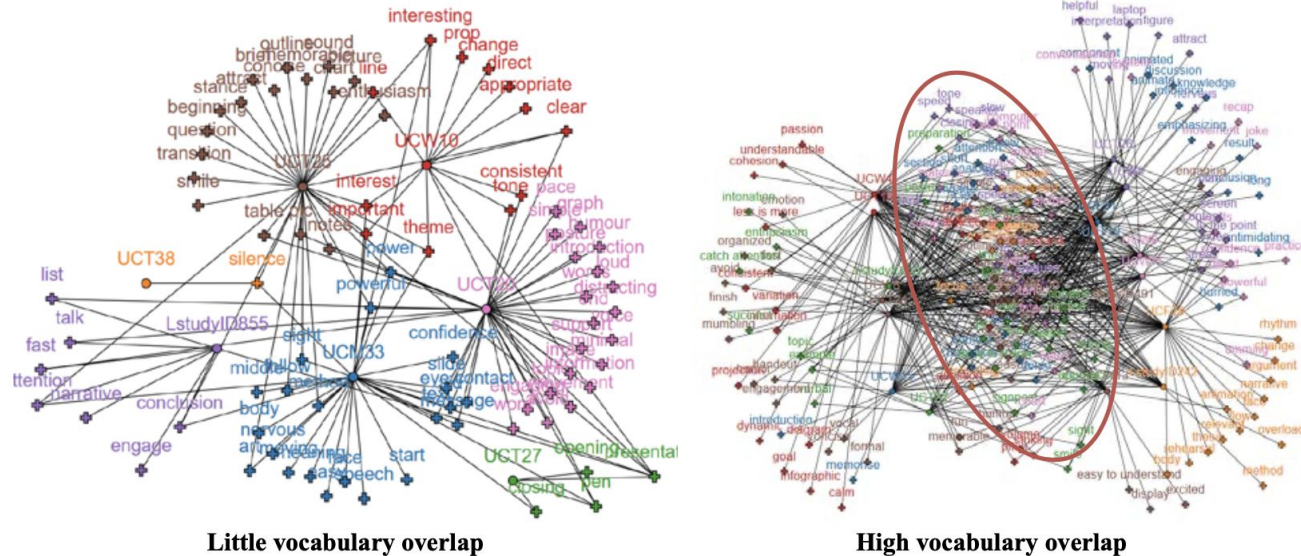


Figure 2. Bi-partite sub-network of learners and vocabulary terms with high modularity (left: habitual video watchers) and low modularity (self-regulated learners).

Hecking, T., Dimitrova, V., Mitrovic, A., & Hoppe, U. (2017, December). Using network-text analysis to characterise learner engagement in active video watching. In *ICCE 2017 Main Conference Proceedings* (pp. 326-335). Asia-Pacific Society for Computers in Education.



Networks are more than social networks

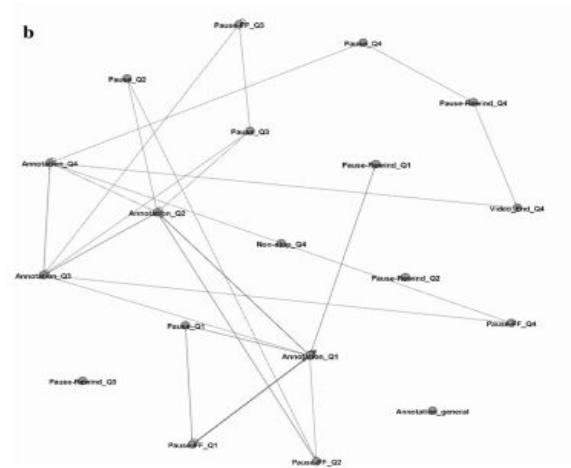
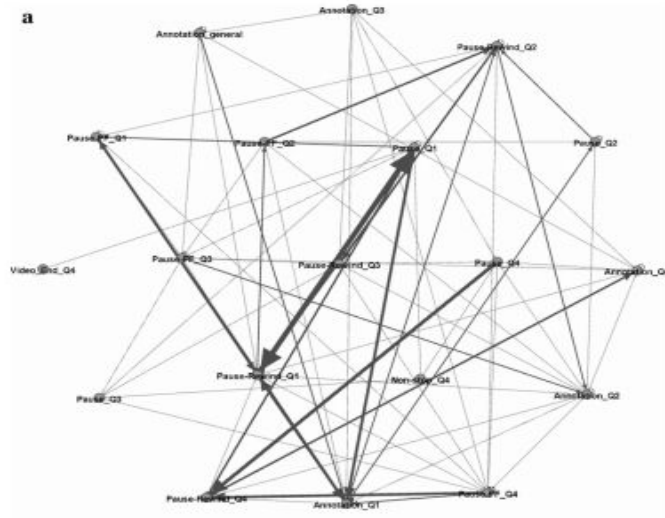


Fig. 3 Examples of transitions graphs of two students enrolled in course 2 (a) and course 4 (b) of the study, respectively

Mirriahi, N., Liaqat, D., Dawson, S., & Gašević, D. (2016). Uncovering student learning profiles with a video annotation tool: reflective learning with and without instructional norms. *Educational technology research and development*, 64(6), 1083-1106.



Networks are more than social networks

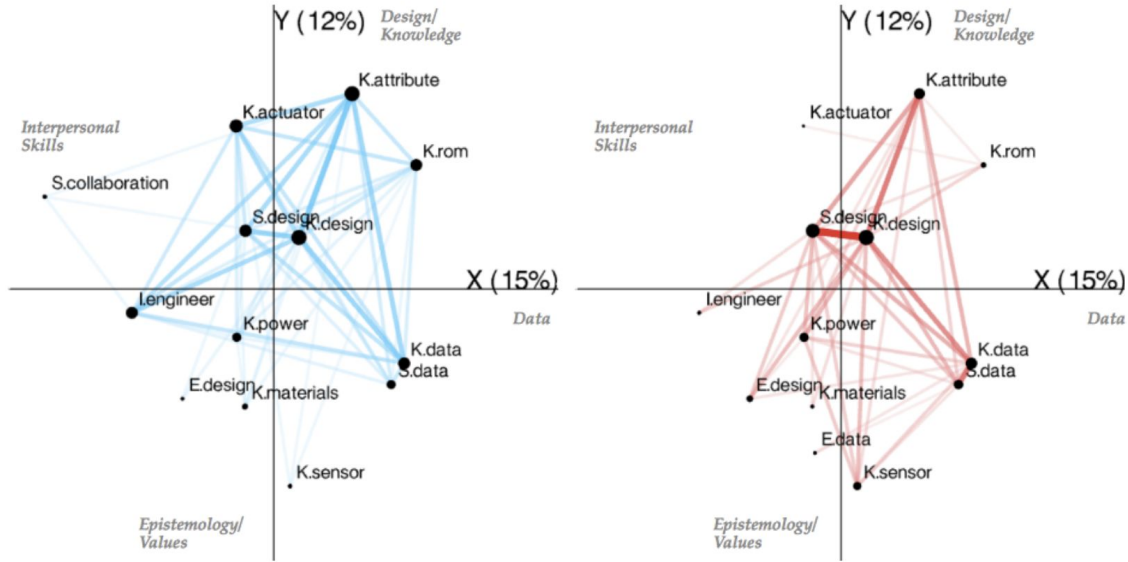


Figure 9. Mean networks of students' from the first (blue, left) and second (red, right) halves of an engineering design simulation.

Shaffer, D., & Ruis, A. (2017). Epistemic network analysis: A worked example of theory-based learning analytics. *Handbook of learning analytics.*



Networks are more than social networks

Also communication and interaction between people

Ties:

- semantic overlap
- artefact use
- timing
- course enrolment
- Composite of the above

ICLS & CSCL works:

- Goggins et al. 2013
- Suthers 2015
- Dascalu, M et al., 2018



Networks are more than social networks

Graphs are **also** often used as a methodology
to analyze socially shared learning
and communication.

Here: networks = graphs = theoretically relevant social learning aspect



Not all centrality measures are equal

Network centralities measure network positioning

Positioning = benefits/constraints from where you are in the network

Similar positioning = similar benefits = possibility for assessment



Not all centrality measures are equal

Note: Positive, statistically significant association
 No statistically significant association

Russo and Koesten

prestige (in-degree) Cognitive learning
centrality (out-degree) outcome

Cho and colleagues

degree centrality
closeness centrality
betweenness centrality } Course grade

Gašević et al.

degree centrality
closeness centrality
betweenness centrality
eccentricity } GPA

Jiang et al.

degree centrality
closeness centrality
betweenness centrality } Course grade



degree centrality
closeness centrality
betweenness centrality } Course grade



Not all centrality measures are equal

Note:  Positive, statistically significant association
 No statistically significant association

Russo and Koesten




prestige (in-degree) 
centrality (out-degree) 

WHY

INCONSISTENCIES?

Jiang et al.

degree centrality  
closeness centrality 
betweenness centrality  } Course grade

degree centrality 
closeness centrality 
betweenness centrality  } Course grade



Not all centrality measures are equal

Tie definitions by Wise, Cui & Jin (2017)



Direct reply

Copresence / Shared thread



Not all centrality measures are equal

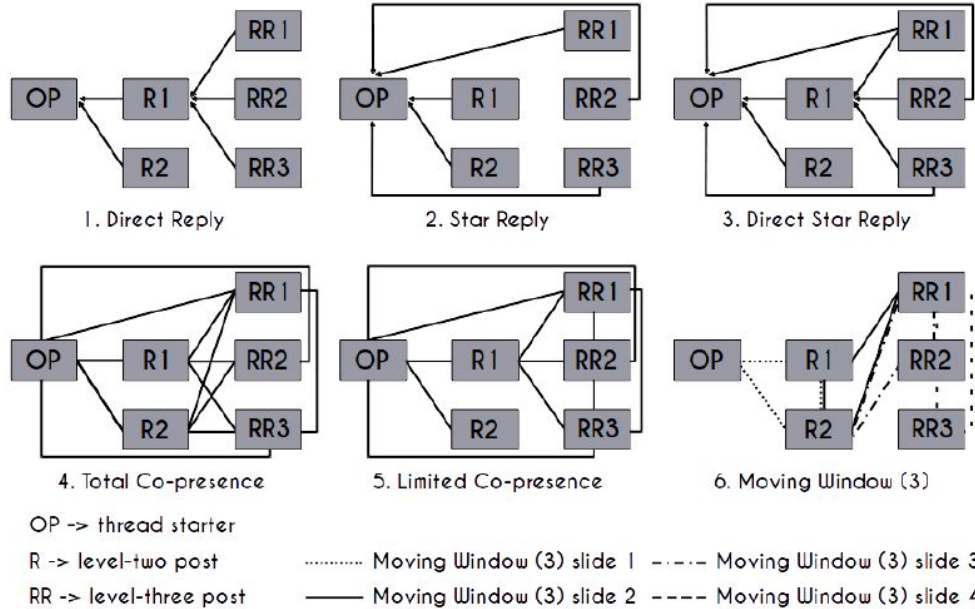


Figure 2: Six Social Tie Definitions

Wise, A. F., Cui, Y., & Jin, W. Q. (2017). Honing in on social learning networks in MOOC forums: Examining critical network definition decisions. *LAK*



Not all centrality measures are equal

Same centrality can reflect different behaviours

- Validity issues:
 - Is this generalizable?
 - What does the metric mean?

Psychometrics, cognitive science, network science, epistemic network analysis - offer a range of approaches to validation

Network models matter.



If network analysis = methodology,
to analyze social learning

Network = graph = construct



Network models matter

“... A network model should be viewed explicitly as yielding a network representation of something”

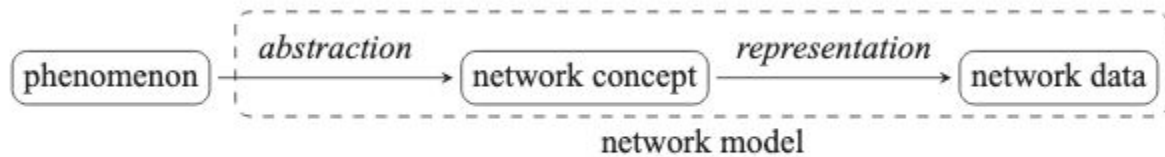


Fig. 1. The elements of network models.



Network models matter

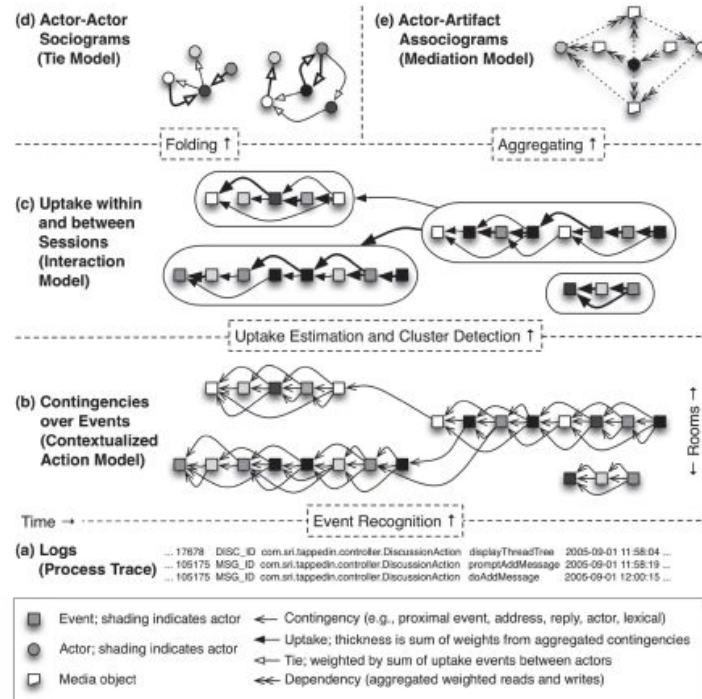


Figure 16.1. Levels of analysis and their representations.

Suthers, D. (2015). From contingencies to network-level phenomena: Multilevel analysis of activity and actors in heterogeneous networked learning environments. *LAK*



Network models matter

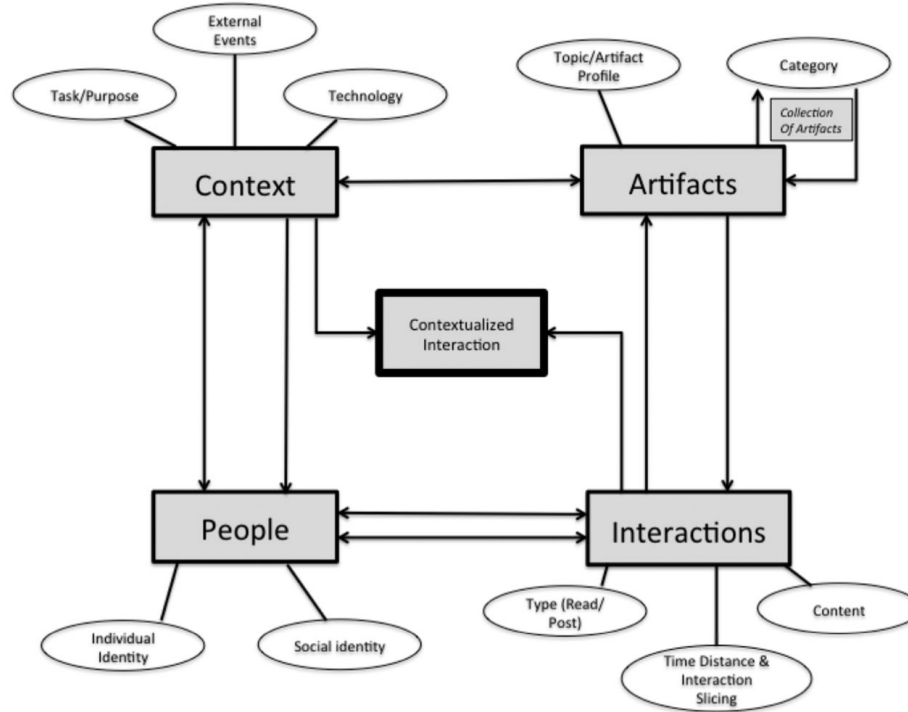
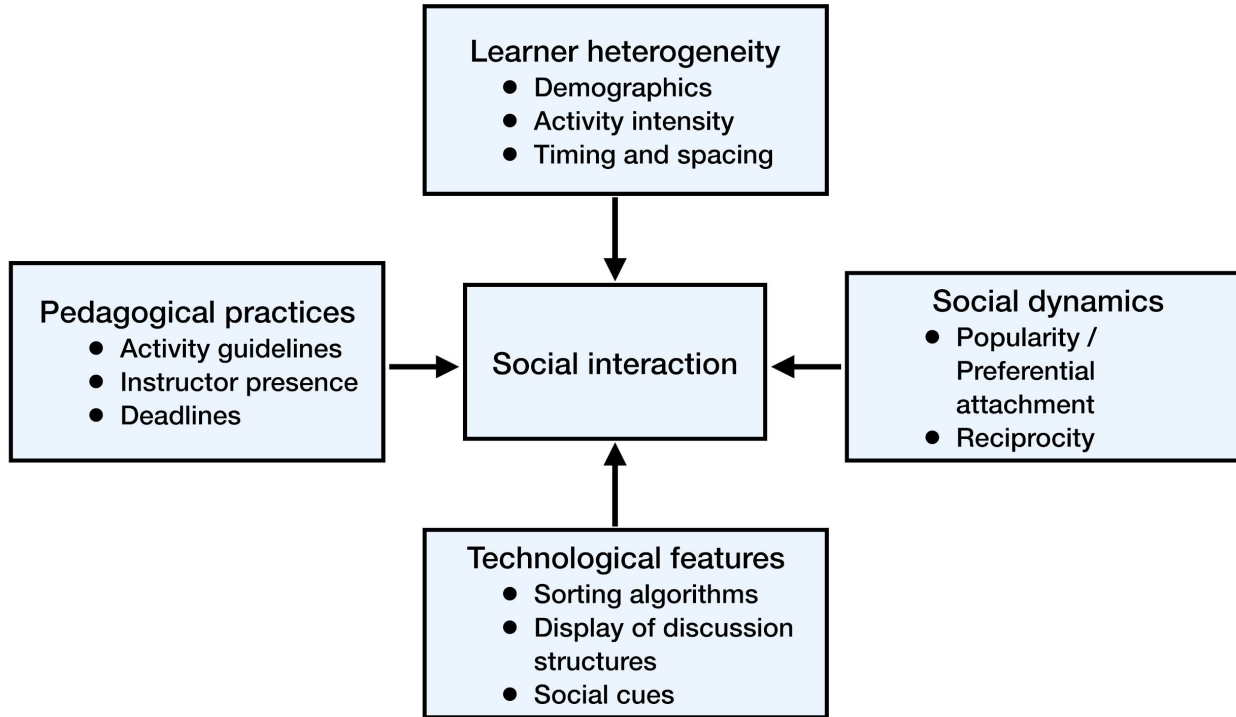


FIG. 1. Model overview of group informatics.

Goggins, S. P., Mascaro, C., & Valetto, G. (2013). Group informatics: A methodological approach and ontology for sociotechnical group research. *Journal of the American Society for Information Science and Technology*, 64(3), 516-539.

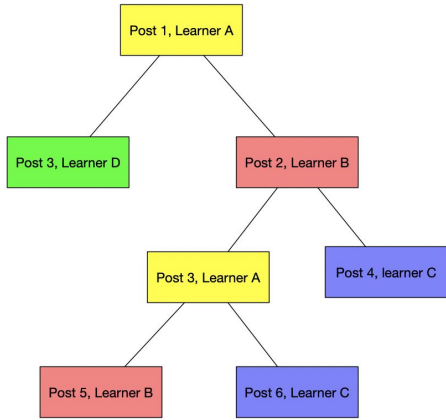


Network models matter

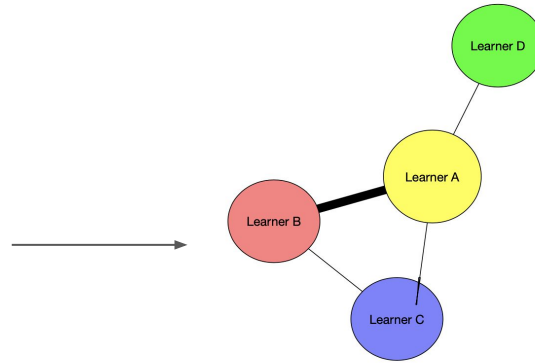




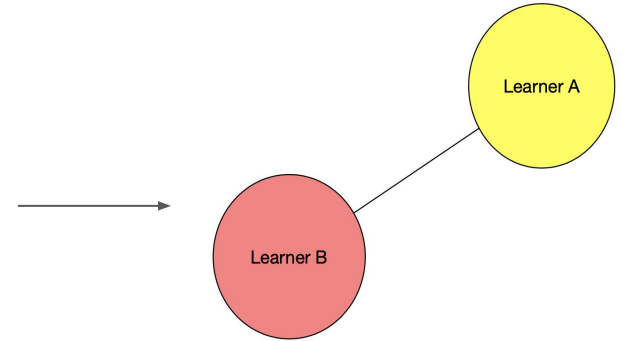
Network models matter



a) Posting network



b) Communication network



c) Social network

Poquet, O., Trenholm, S., Santolini, M. (n.d.). Multi-level Approach to Online Forum Evaluation: From Posts to Communication Patterns to Learner Networks.

Network evaluation is subjective & multi-dimensional.



Network evaluation is subjective & multi-dimensional.



Social learning is multi-level and multi-dimensional

Separating the levels enables differential indicators

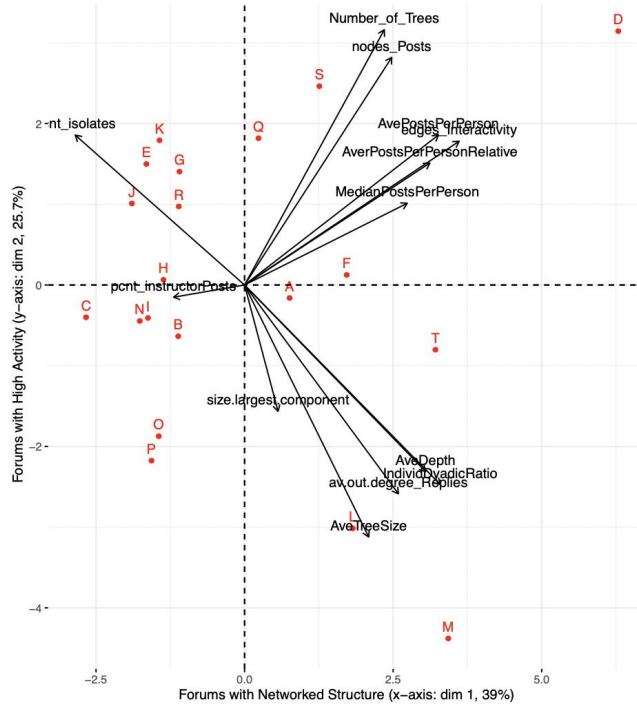
Evaluation in LA = Instructor choice of what indicators matter

No one 'effective' network = fit for purpose



Evaluation is multi-dimensional

Q3



Q1

Evaluating posting behavior

Q1 High Activity; High Turn-Taking

Q2 Moderate Activity; High Turn-Taking

Q3 High Activity; Low Turn-Taking

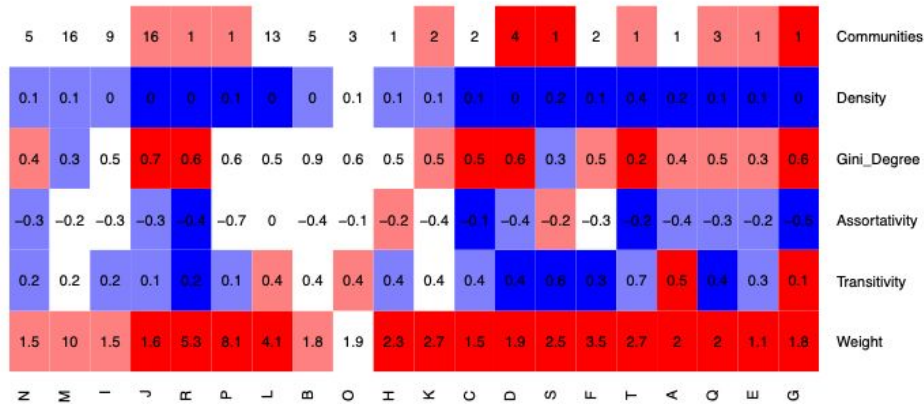
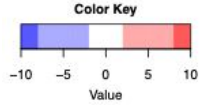
Q4 Low Activity; Low Turn-Taking

Q2

Figure 3. Principal Component Analysis Bi-Plot Structuring Forums and Posting Activity Indicators



Evaluation is multi-dimensional



Evaluating communication structure

Q1 Communities, inequality

Q2 No communities, equality

Q3 High dyadic exchange, pockets of exchanges

Q4 High centralization



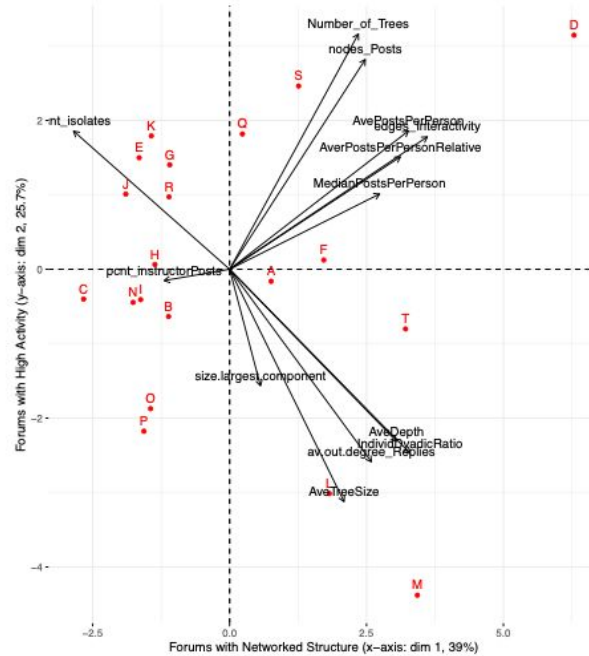
Evaluation is multi-dimensional

Evaluating communication structure

Forum K
'Share your opinion on X'



Forum P
'No special forum provisions'



Forum D
'Constrained small groups weekly assessed'



Forum M
'Post a response or build on the opinion of X people'





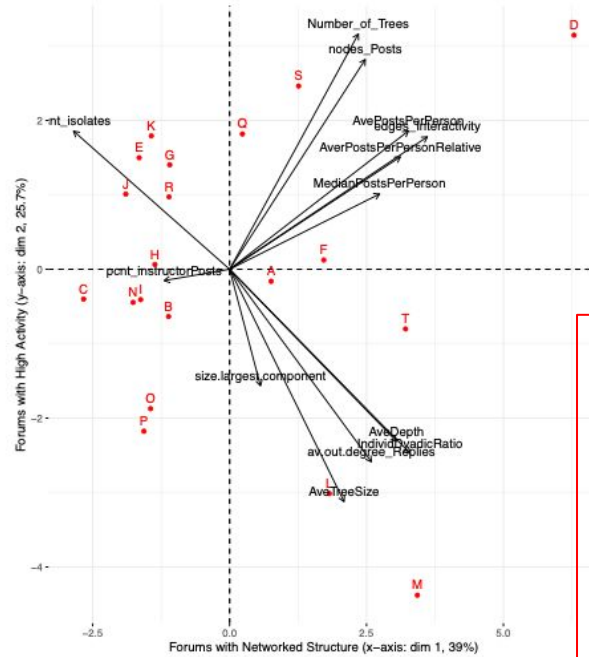
Evaluation is multi-dimensional

Evaluating communication structure

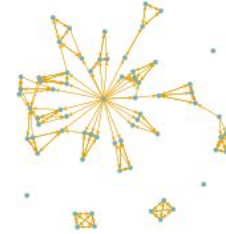
Forum K
'Share your opinion on X'



Forum P
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Forum D
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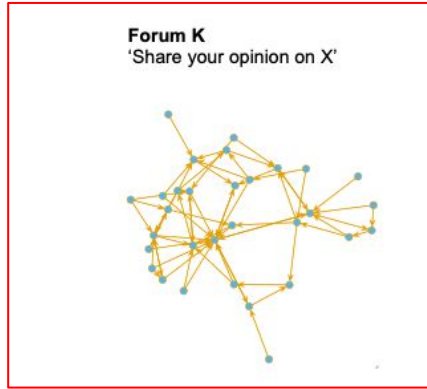
Forum M
'Post a response or build on the opinion of X people'



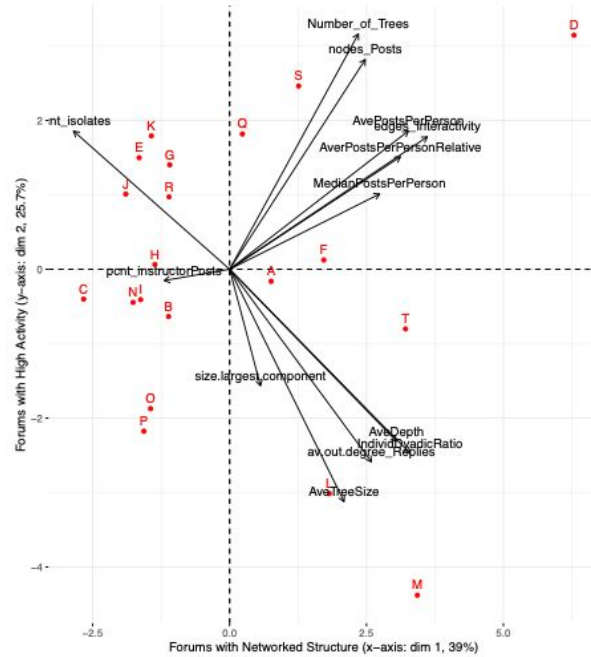


Evaluation is multi-dimensional

Evaluating communication structure



Forum P
'No special forum provisions'



Forum D
'Constrained small groups weekly assessed'



Forum M
'Post a response or build on the opinion of X people'



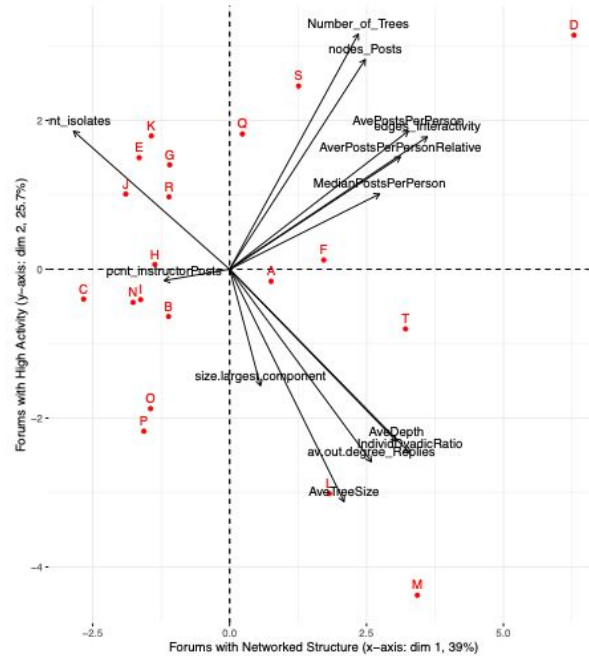
Evaluation is multi-dimensional

Evaluating communication structure

Forum K
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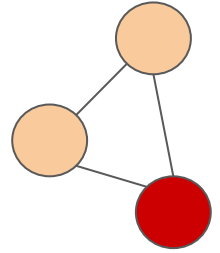
Applied Network Analysis: Core Messages



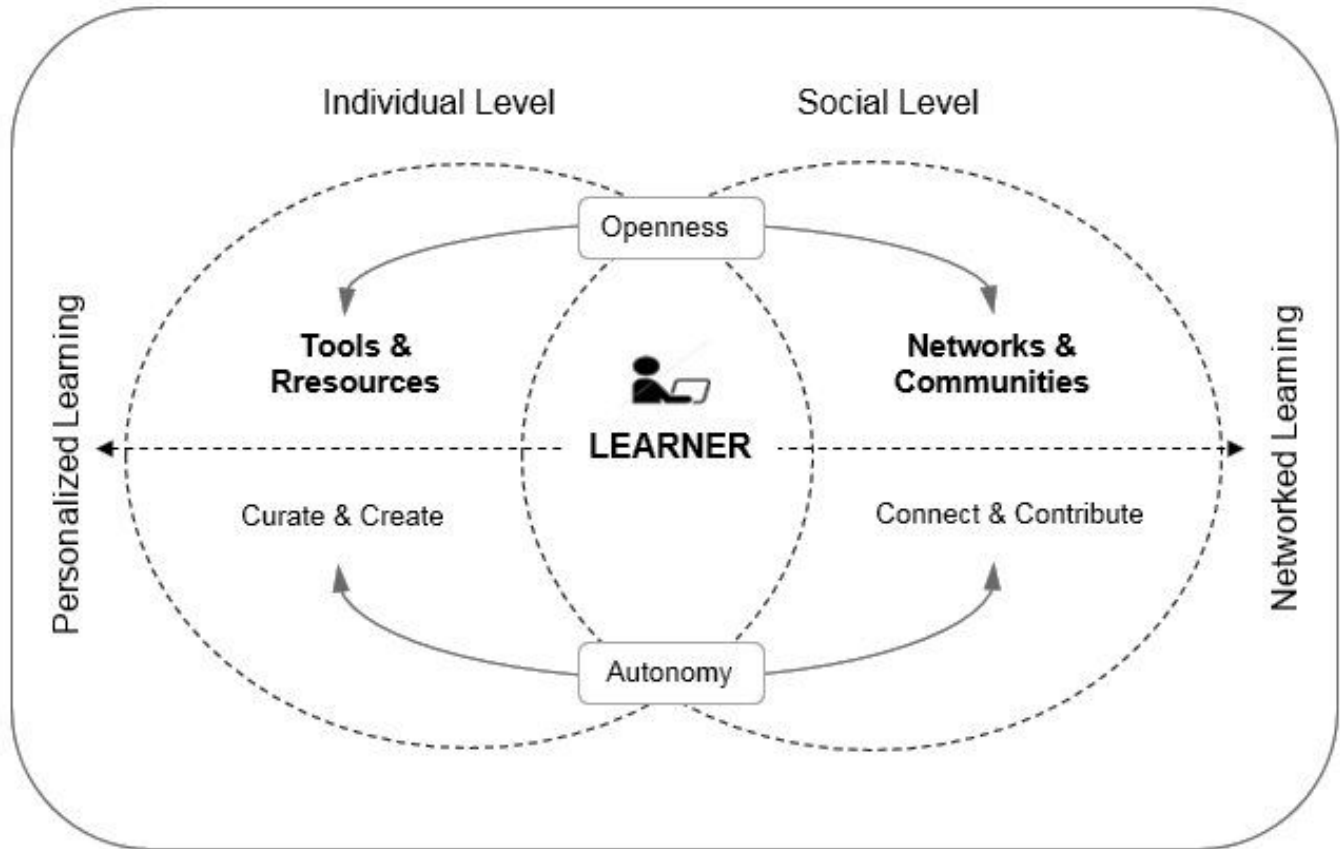
- **Networks are much more than social networks**
- **Not all centralities measures are made equal**
- **Network models matter**
- **Network evaluation is subjective and multi-dimensional**

How network analysis can be used to support teaching and learning?

Applying Network Analytics in Teaching



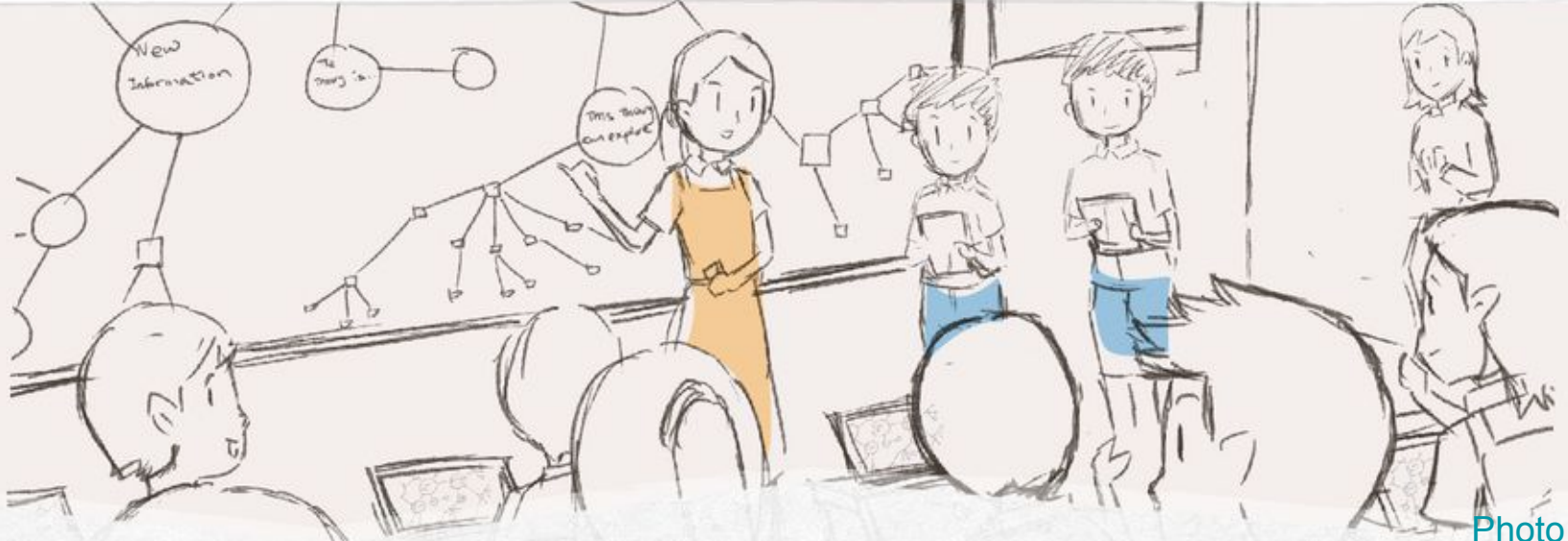
- **Learning as a networked phenomenon.**



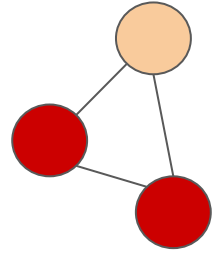
Networked learning

The open networked learning ecology in cMOOCs
(Saadatmand, 2016)

Knowledge Building Community



Applying Network Analytics in Teaching



- Learning as a networked phenomenon.
- **Socio-technical systems facilitate networked learning.**

← #RemoteLearningChat

Top Latest People Photos Videos

Ms. Mulvey @Ms_Mulvey4 · Apr 16
 Replying to @TowsonISTC
 A2: The special educators at my school have been working so hard to meet and speak with their caseloads on a daily basis. They make sure the students are getting the support they need. I also don't set time limits for when work needs to be turned in. [#RemoteLearningChat](#)

2 1 10

Dr. Jeff Kenton @DrJKenton · Apr 16
 A1: I worry about my students in the best of times. For students with disabilities in this pandemic, the concerns get more fundamental (food, clothing, shelter) and elemental (assistive tech, wifi, aides if they need them) [#RemoteLearningChat](#)

1 7

Ms. RosencransART @MsRosencransART · Apr 14
 A3: Work to figure out who has access, who has limited access, and who has none. Work to make contact with those students who are missing out. [#remotelarningchat](#)

3 7

flipgrid.

1 Teachers create grids of questions

2 Students respond with video

3 Everyone views and shares

23 October

When you hear the term **universal design**, what is the first object that comes to mind?

Stacy Luke Tatum

Dennis

When you hear the term **universal design**, what is the first object that comes to mind?

[Photo Credit](#)

Social media



Layers of Annotation

Built on Open Standards

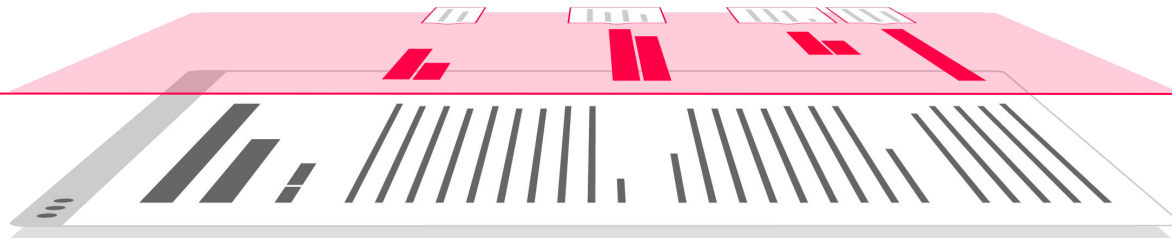
General Public



UMN SNA Course

Expert
Community

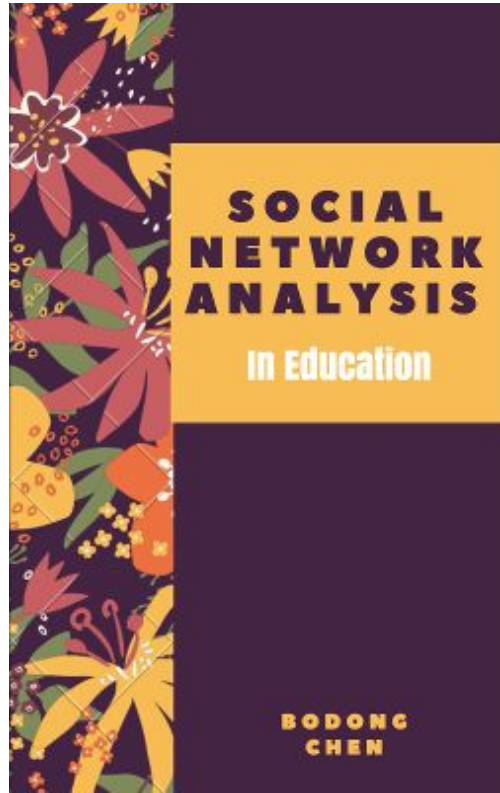
Private
Notes



Any Website, Article, eBook, Document, Multimedia

(Credit: Angell, Dean, et al., *EDUCAUSE 2018*)

See <https://bookdown.org/chen/snaEd/>



Chen, B. (2019). Designing for Networked Collaborative Discourse: An UnLMS Approach. *TechTrends*, 63(2), 194–201. <https://doi.org/10.1007/s11528-018-0284-7>

Structural Measures for Complete Networks

Find in this chapter Sections

Example Data

To demonstrate these concepts and measures, this chapter will rely on a fairly simple network data set: Newcomb's Fraternity Data (referred to as Fraternity Data). The original sociometric data collected by Newcomb required each of the 17 actors (all members of the same fraternity) to rank all the others in terms of friendship preferences, ranging from 1 to 16, with 1 indicating first preference. These rankings were done across the entire semester, resulting in 15 separate 17×17 single-mode, directed, and valued matrices. However, to better illustrate these concepts and measures, these data have been transformed to keep things a little simpler. In addition, the focus will be on one of these networks at a single point in time (week 0, the beginning of the study). These recoded data have been dichotomized, with friendship rankings ranging from 1 to 3, now coded as 1, 0 otherwise. Therefore, using the terminology introduced in Chapter 4, the recoded data set is now directed (asymmetrical) and binary (nonvalued). **This was done simply for purposes of presentation; any manipulation of network data should have some theoretical or empirical basis.** Table 5.1 shows the recoded data file in the node-list format, with each row starting with the ID number of the responding student followed by three other ID numbers, the alters

Table 5.1 Transformed Fraternity Data in Node-List Format. These binary and directed data consist of 17 students, numbered 1 through 17 (column 1). The next three columns are the ID numbers of the alters who have "received" a tie. For example, Student 2 has sent a tie to Students 4, 7, and 16.

1	11	13	17
2	4	7	16
3	11	12	17
4	2	7	17
5	11	12	17
6	4	8	13
7	4	12	17
8	6	10	11
9	11	12	17
10	1	17	15
11	9	12	17
12	3	11	17
13	1	6	15
14	7	9	10

Public

Show all annotations (35)

1

dichotomized

How were the data changed from 1,2,3 to 1,0?

#term #SNAed

Feb 20

This was done simply for purposes of presentation; any manipulation of network data should have some theoretical or empirical basis.

So are 'purposes of presentation' valid basis for data manipulation? I am left yearning for more explanation.

#SNAED #question

3

Hide replies (3)

2

tell me more about your question!

#SNAED

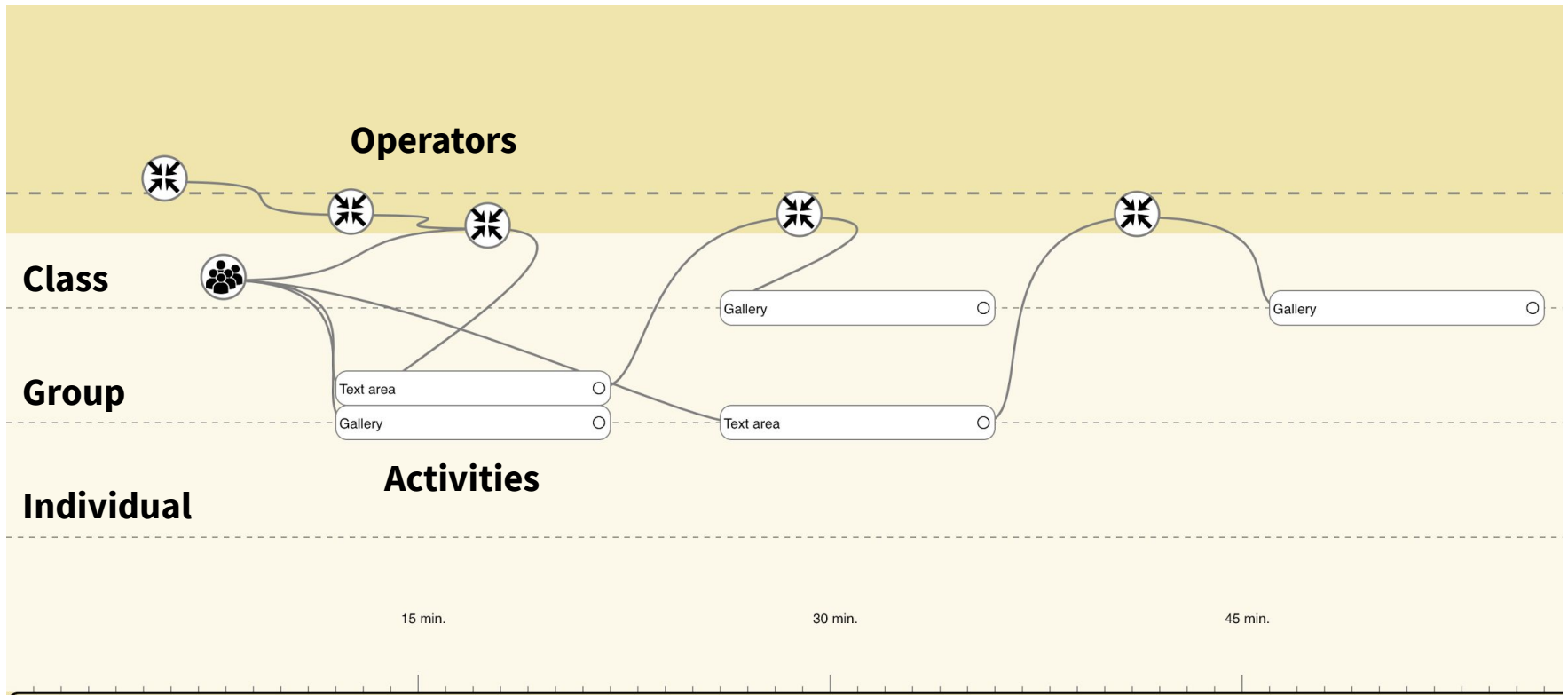
Feb 20

I gathered that the author made the decision to code friendship rankings 1-3 as 1 and all others as 0. The author says this was done for purposes of presentation. This seems like a thin explanation to me. I'd be curious in hearing why only the top three friendship edges are considered. Is there a theoretical basis for only the top three? If not, is the authors arbitrary decision to code the top three rankings for purposes of presentation valid? Perhaps for the purposes of this example the author isn't rigorously laying a theoretical foundation, which may make the chapter easier to read. I was just wondering. Thanks Bodong!

#SNAED

Feb 20

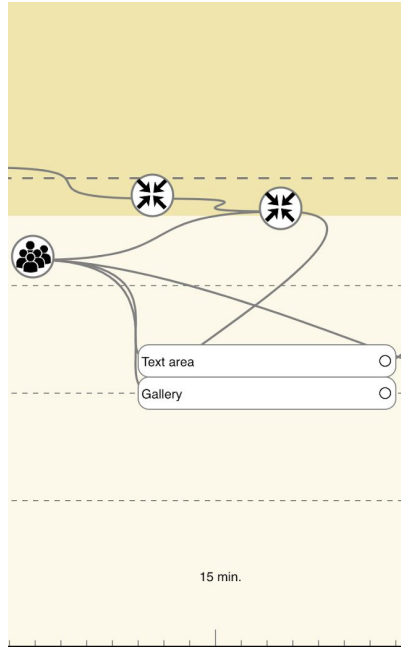
1. Annotations of readings
2. Replies to annotations



Synchronous collaborative activities on [FROG](#) (by Stian Håklev)

Chen, B., Shui, H., & Håklev, S. (2020). [Designing orchestration support for collaboration and knowledge flows in a knowledge community](#). To appear in the *Proceedings of the 14th International Conference of the Learning Sciences (ICLS)*.

FROG activity 1



1

██████████ on "Tools for Educational Data ..." Tue Oct 09 2018

its ability to integrate data from multiple sources (e.g., a .csv of engineered features, a word document of text responses, and a database of student demographics) within the same analysis.

This is awesome. I would love having all of this from one tool in a single analysis, especially the text responses.

[Click to hide replies...](#)

██████████ Sat Oct 13 2018

Yes!!! I wonder if this might be useful in text/discourse analysis.

██████████ Sun Oct 14 2018

Same^ tagging this for the discourse SIG.

██████████ on "Tools for Educational Data ..." Tue Oct 09 2018

RapidMiner can be used to conduct cross validation at multiple levels (such as student-level cross validation or lesson-level cross validation)

If I'm understanding the meaning of this correctly, then this could be very useful for the type of data I work with. It would be important to validate that a trend existed across multiple students and assessments before drawing any general conclusions.

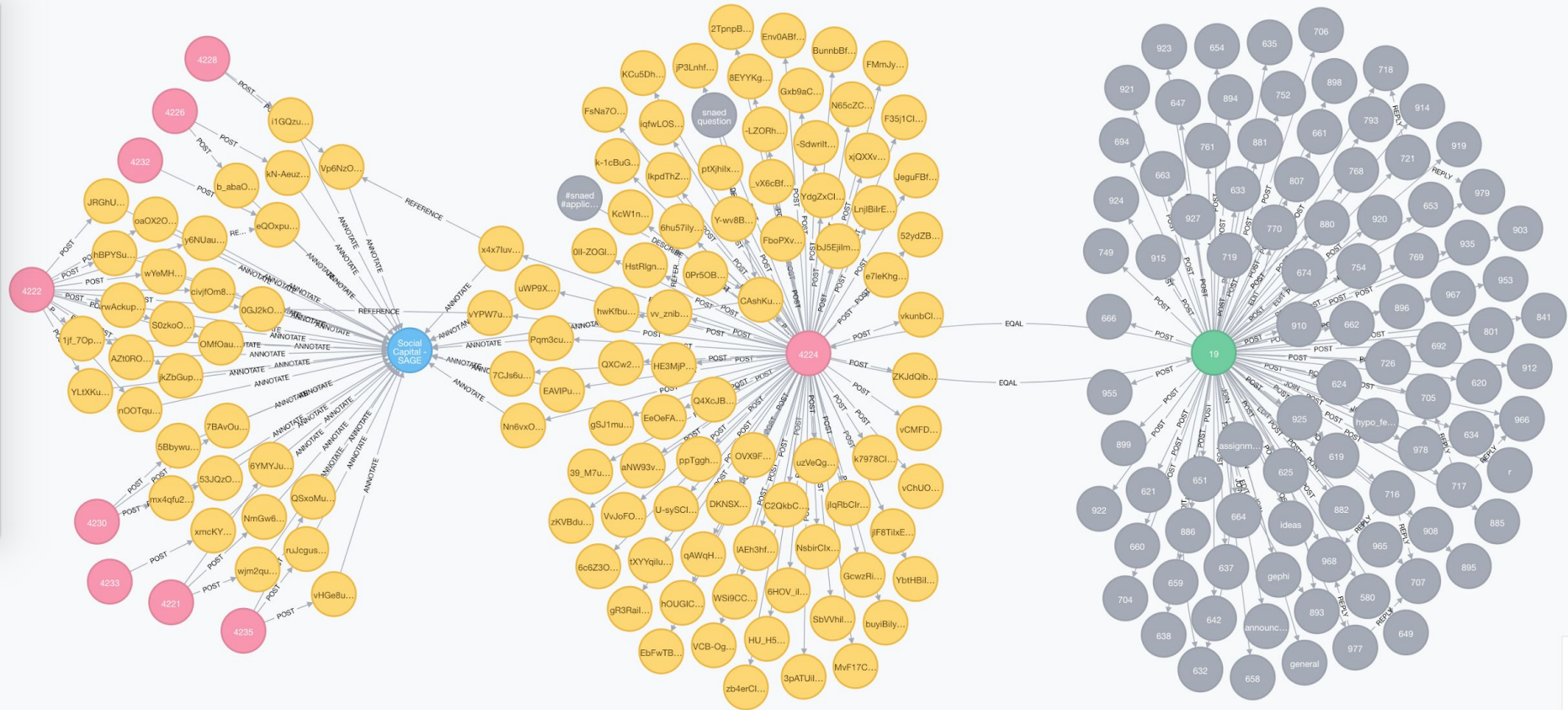
Text area (group/2)

2

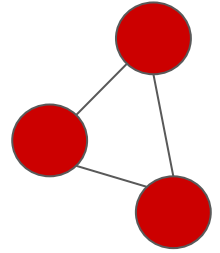
What were the most important ideas in web annotations?

Please spend some time to process annotations initiated by members of the group. Jot down notes about the following: 1. Any general ideas about using learning theory in learning analytics; 2. For Reading #2 (about SRL in MOOCs), identify: a) one area that the study did well in applying SRL ("Praise"), b) one area of theory use the study could be improved ("Push").

1. Annotations imported via Hypothesis APIs
2. Group note-taking in Zoom breakout rooms



Applying Network Analytics in Teaching



- Learning as a networked phenomenon.
- Socio-technical systems facilitate networked learning.
- **Network analytics apps empower reflection and action-taking.**



[SNAPP](#) (Bakharia & Dawson, 2011)

Some ethical questions come up as Euthanasia start engaging in more and more human life. I cannot anticipate what opinions Budinger will discuss in Chapter 7, but it is a fact that this issue is very complex and unwieldy.

Reply (4 likes)



24 Sep 2015

We deal with same topic even though for your information, in Korea, euthanasia there are countless people who reject are only four states which are accept Washington, and Vermont).

Reply (1 likes)



Interesting.

If we were to get into the second of the think about the following?

- Unassisted Euthanasia (Suicide): life, without a doctor?
- Friend-assisted Euthanasia: what member to do it? Does that impact
- Postponed-Permit Euthanasia: what complete an array of tests (for ch

CanvasNet

This app helps you see the big picture of our class discussion on Canvas.

-- built for Canvas LMS, with ♥

Course Section

Section

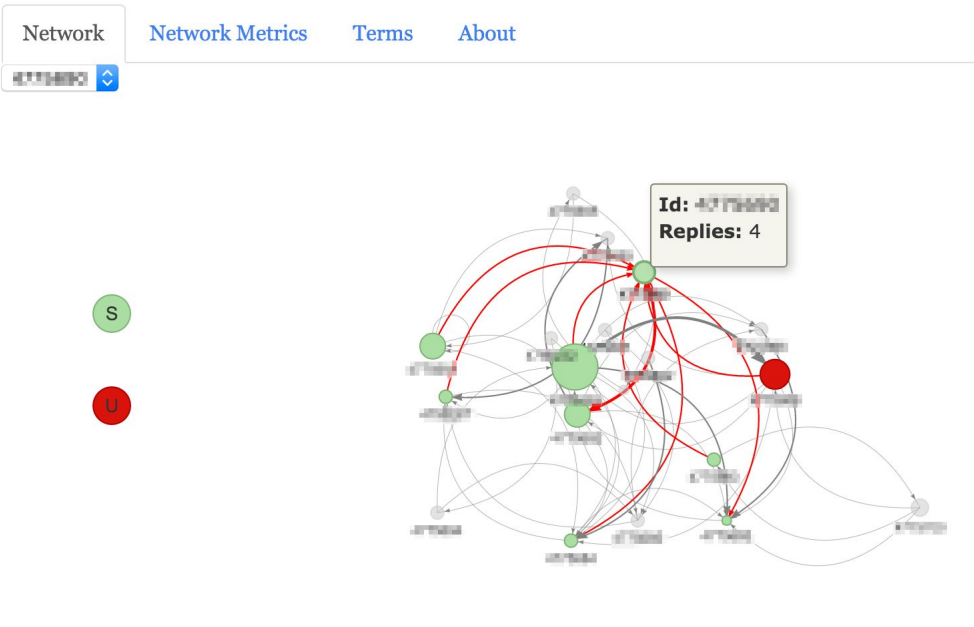
Date Range

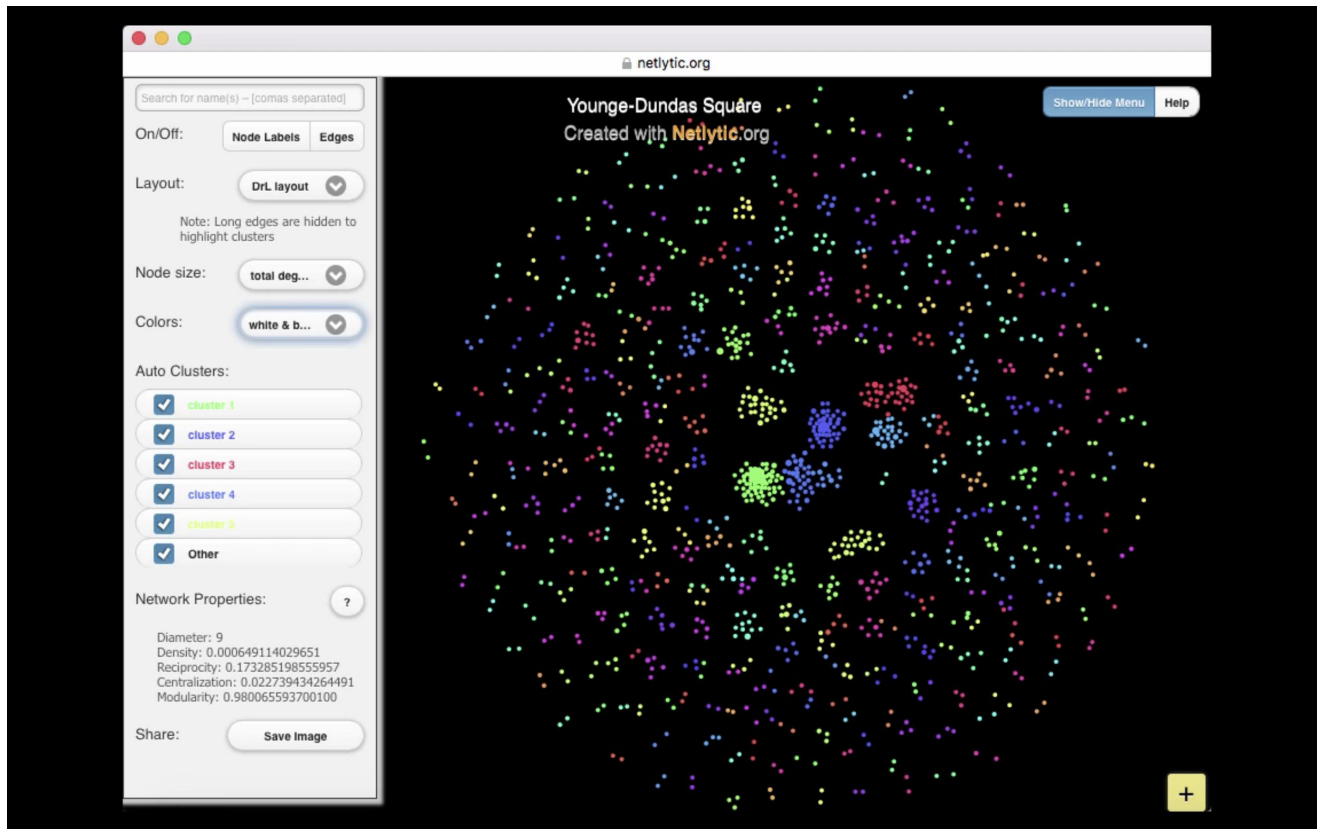
2015-11-06 to 2015-11-20

Your Canvas Id

Hide Teacher

Update



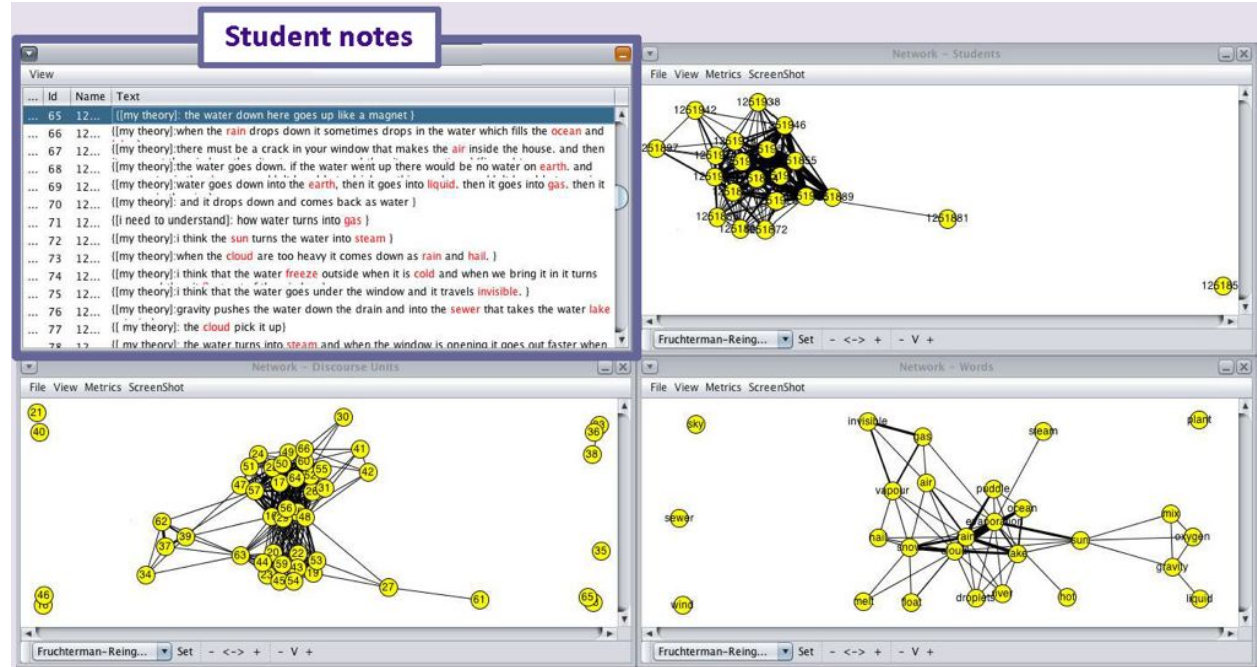
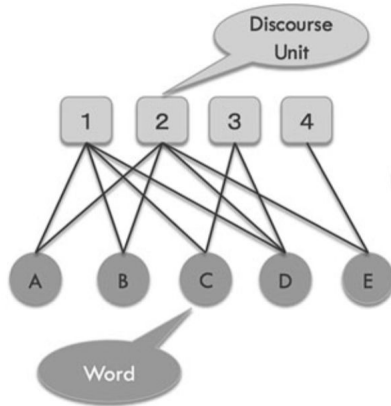


Netlytic (see <https://netlytic.org/>)

Gruzd, A., Paulin, D., & Haythornthwaite, C. (2016). Analyzing Social Media And Learning Through Content And Social Network Analysis: A Faceted Methodological Approach. *Journal of Learning Analytics*, 3(3), 46–71. <https://doi.org/10.18608/jla.2016.33.4>

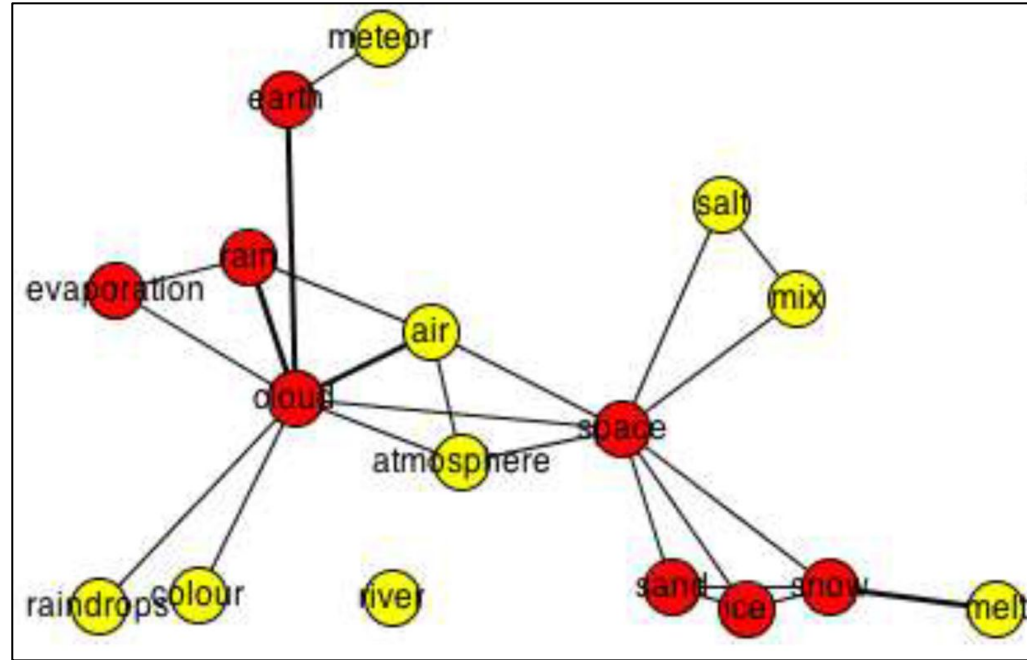
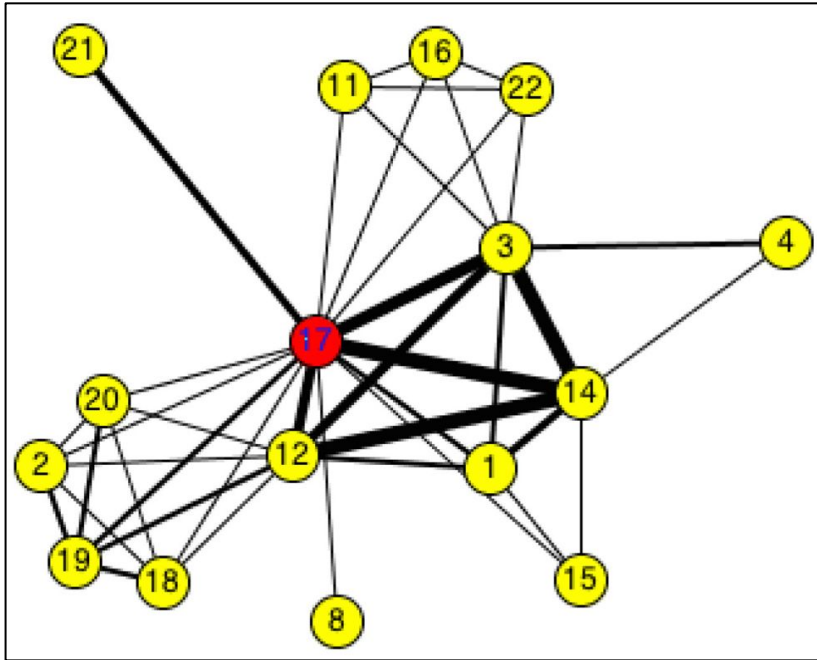
Socio-semantic networks based on KBDeX

(Oshima, Oshima, & Matsuzawa, 2012)

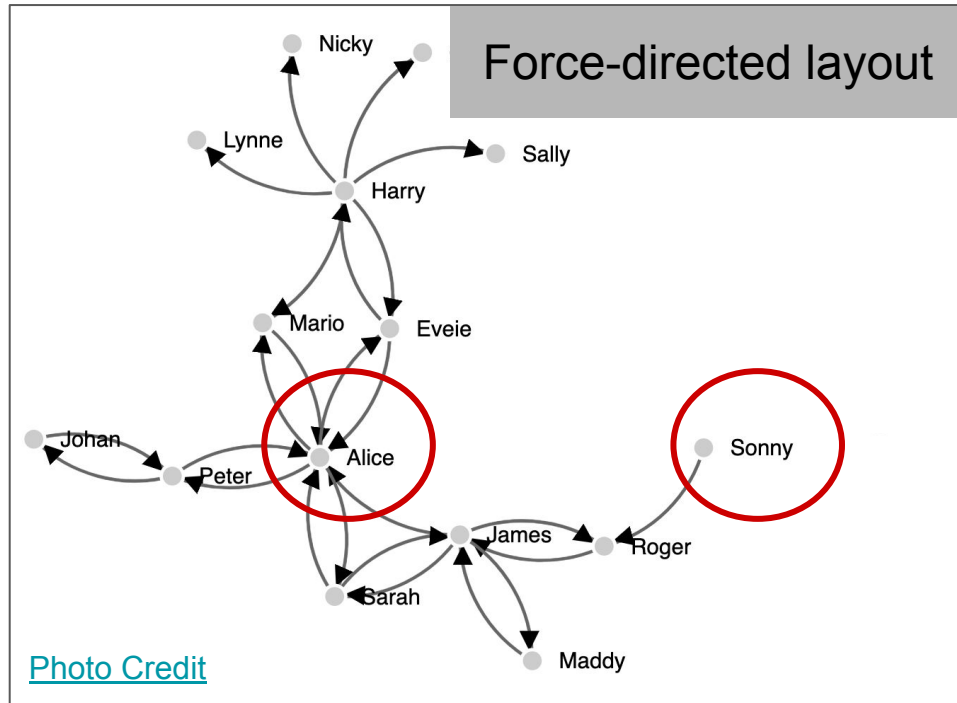


Ma, L., Matsuzawa, Y., Chen, B., & Scardamalia, M. (2016). Community knowledge, collective responsibility: The emergence of rotating leadership in three knowledge building communities. In *The International Conference of the Learning Sciences (ICLS) 2016, Volume 1* (Vol. 1, pp. 615–622). Singapore.

Knowledge building in grade 1



Ma, L., Matsuzawa, Y., Chen, B., & Scardamalia, M. (2016). Community knowledge, collective responsibility: The emergence of rotating leadership in three knowledge building communities. In *The International Conference of the Learning Sciences (ICLS) 2016, Volume 1* (Vol. 1, pp. 615–622). Singapore.



Alice



Sonny

Sense of belonging

Self-image

Word of caution: implicit biases and value tensions

Conclusions and take-aways

Networks in digital learner traces - method and methodology

Generalisability and interpretability are critical

Multi- models reflect complexity

Distributed tools scaffold and support networked view on learning and teaching

Thank You!

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