

The story of the Moscow Electronic School educational community, told using network analysis and agent-based modelling

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The usual story – 100 users + 112 pages

- This is a familiar story that is told about an online community where 100 users have created 50 pages or digital stories.
- The way we look at the system and the way we talk about the system matters. Typically, communities are viewed through the lens of time of existence, the number of registered users, the number of objects created by users and messages posted by users. Most of the time, this simple story is available on the community homepage or easily obtained upon request.
- For example, if you write the magic MediaWiki words on any Wikipedia page, you can immediately find out how many registered participants are in the system and how many pages they have create or edit.





* number of users = ""{{NUMBEROFUSERS}}""	number of users = 42,306,169
* number of pages = ""{{NUMBEROFPAGES}}""	number of pages = 54,294,400
* number of editing = ""{{NUMBEROFEDITS}}""	number of editing = 1,043,084,920
* number of articles = ""{{NUMBEROFARTICLES}}""	number of articles = 6,386,680

Main point of my talk is that communities and especially virtual learning communities stories are not about users or digital objects - documents, photos, or programs. These stories are about network structures, groups, teams and other alliances which emerges between users and objects.

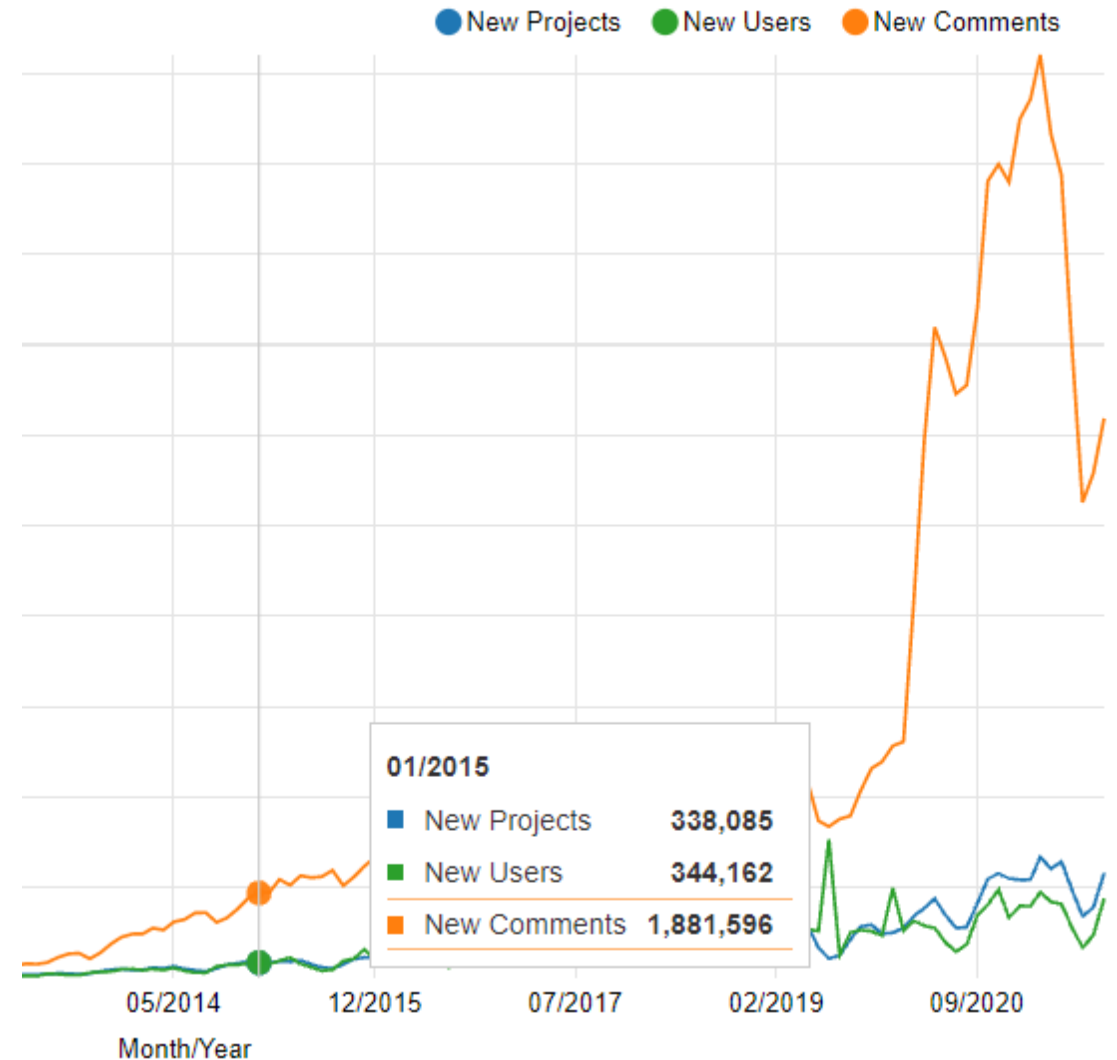
Users, objects and time

- <https://scratch.mit.edu/statistics/>

Community statistics at a glance

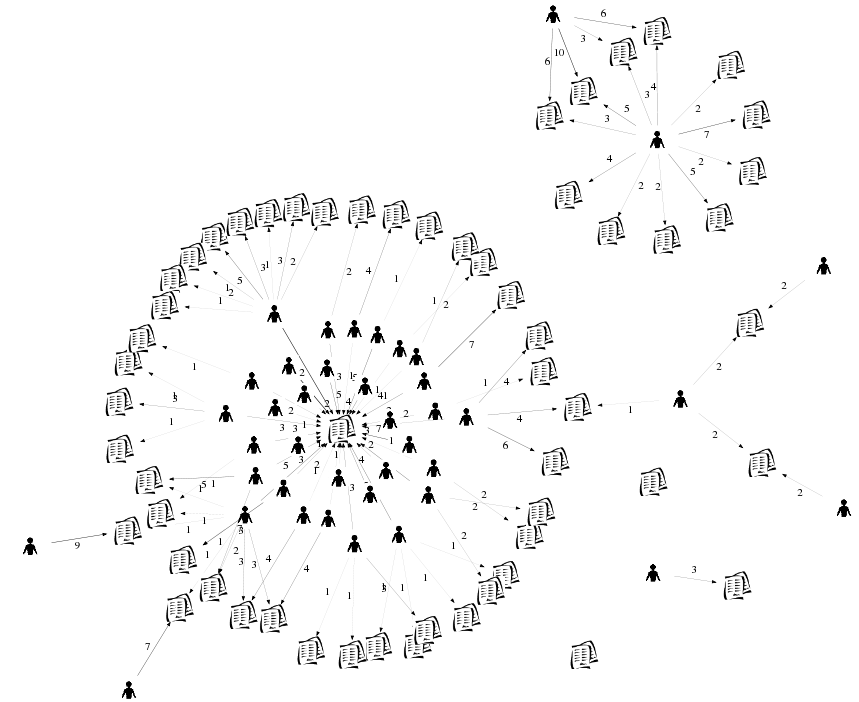
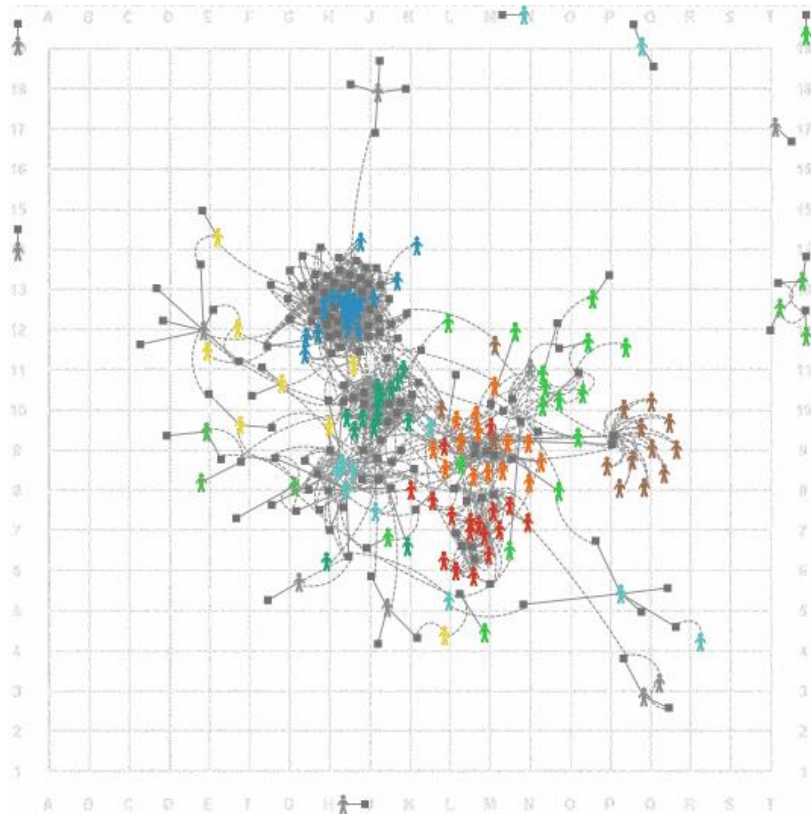
 **85 556 176** projects shared,
 **77 383 081** users registered,
 **526 791 585** comments posted,
 **29 809 092** studios created
...and growing!

Here we can see the dynamics of users registration and their creation of objects and comments. However, this is about users, but not their relationship.



Users, objects, time and links

- <http://letopisi.org/index.php/WikigramSandbox>



What I try to do on the field of different educational communities is to find a structure or dynamical relation between users and social objects which they create and reused.

User Generated Content or Collective Design Systems

Community	Social object	Action
ACM Library https://dl.acm.org/	Article	Write -> Cite -> Write together
Globaloria globaloria.com	Computer game	Play -> Plan -> Prototype -> Program -> Publish
Scratch scratch.mit.edu	Scratch project	Imagine -> Create -> Play -> Share -> Remix
NetLogo Modeling Commons modelingcommons.org	NetLogo model	Create -> Run -> Share -> Comment -> Modify -> Create variations
StarLogo TNG www.slnova.org	StarLogo 3D model	Design -> Build -> Test/Tinker/Play -> Design
Looking Glass lookingglass.wustl.edu	3D story	Create -> Animate -> Share -> Remix
CloudWorks cloudworks.ac.uk	Learning Design (Compendium LD)	Find -> Share -> Discuss
WebGrid webgrid.typed.com	Repertoire Grid	Display -> Cluster -> Map -> Crossplot -> Matches -> Compare
Letopisi.org	Wiki page	Read -> Create -> Edit -> Connect -> Share -> Read
Preobra.ru	Part of document	Rate -> Discuss -> Suggest your version
Moscow Electronic School uchebnik.mos.ru	Learning Scenario	Evaluate -> Upload -> Copy -> Upload -> Run the object in the lesson -> Embed the object in the assignments

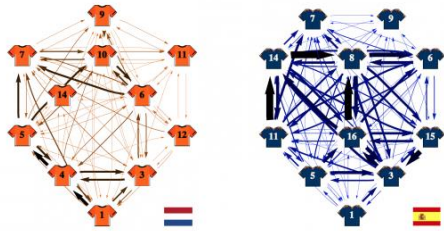
There are huge variety of user generated content community where we can use this approach. I have mentioned here only the most favorite examples.

Collaboration of learners in various collaborative environments (Wiki, Scratch, etc.) is quite often the subject of study and design. However, teacher collaboration has been studied much less frequently. May be the best example is frozen British community CloudWorks

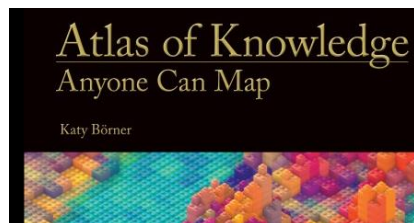
Network Science and Network Analysis

- Network science is the study of network representations of physical, biological, and social phenomena leading to predictive models of these phenomena. We will never understand complex systems unless we develop a deep understanding of the networks behind them (Barabási, 2016).

Netherlands vs. Spain



- **Ubiquity of networks.** Networks are pervasive across all aspects of life: biological, physical, economic, and social. Every system can be understood as a network that consists of nodes (actors) and the edges (links) that connect the nodes.
- **Democratization and Accessibility of Networked Science.** Today "Anyone can map" and this situation promote network thinking among students and teachers.



It was not so easy to discover and map social structure. That is why we need special tools of Social Network Analysis and ABM to augment our stories.

Network science in a school classroom

By postulating a friendship network in a school classroom of 25 students, we have taken a theoretical step that is non-trivial. We have supposed that separate individuals are not an adequate representation, moreover that even separate dyads are insufficient; rather, that there is a unity within the classroom that makes it proper to talk of «a» network, not 25 children or 300 dyads.

To conceptualize the classroom in network terms is an implicit (and strong) claim that connectedness across individual elements is fundamentally important so that the classroom can be thought of as one «system».

(Brandes, Robins, McCRANIE, & Wasserman, 2013)

Moscow Electronic School

- The library of the Moscow Electronic School is a rather complicated system with multiple roles offered to users.
- The actors of the repository are teachers, students, parents, and publishers – anyone performing any actions with digital objects
- Number of lesson scripts created **1 762 025**
- Number of lesson scripts published **56 714**
- Number of authors **84 289**
- Number of authors of published scripts **10 566**

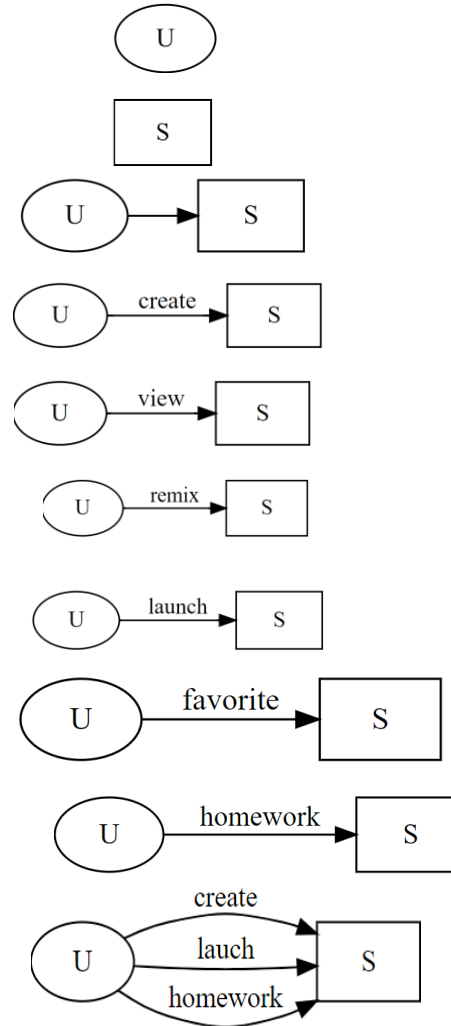
The screenshot displays the website's navigation bar with categories: Материалы РЭШ, Сценарии темы, Сценарии урока, Приложения, Задания, Тесты, Видеоуроки, Книги, Пособия, and Видео. Below the navigation is a grid of lesson script cards. Each card includes a subject, a title, a grade level, an author's name, a date, the number of fragments, and a rating. The cards shown are:

- ТЕХНОЛОГИЯ**: Щенок в технике оригами (Grade 1, 2, 3, 4; Author: Евстифеева Дарья Олеговна; 10 fragments; Rating: 4.4 (30))
- ТЕХНОЛОГИЯ**: Бабочка в технике оригами (Grade 1, 2, 3, 4; Author: Евстифеева Дарья Олеговна; 9 fragments; Rating: 4.5 (47))
- МАТЕМАТИКА +1**: Понятие вектора. Равенство векторов (Grade 7, 8, 9; Author: Шишачкая Ольга Алексеевна; 13 fragments; Rating: 4.8 (37))
- МАТЕМАТИКА**: Площадь трапеции (Grade 8; Author: Шишачкая Ольга Алексеевна; 12 fragments; Rating: 4.6 (70))
- АНГЛИЙСКИЙ ЯЗЫК**: Conditionals 2, 3. Lesson 3 (Grade 8, 9, 10, 11; Author: Козарезова Татьяна Ивановна; 8 fragments; Rating: 4.8 (67))
- АНГЛИЙСКИЙ ЯЗЫК**: 6f. Starlight 8. Animal talk. Do you speak dolphinese? Extr... (Grade 8, 9; Author: Тюляева Мария Александровна; 17 fragments; Rating: 4.6 (12))
- АНГЛИЙСКИЙ ЯЗЫК**: Spotlight 4. Module 1. Family & friends! My best friend! (Grade 4; Author: Сергеева Екатерина Васильевна; 12 fragments; Rating: 4.2 (21))
- АНГЛИЙСКИЙ ЯЗЫК**: Spotlight 4. Starter Unit. Back together! Lesson A & B (Grade 4; Author: Сергеева Екатерина Васильевна; 15 fragments; Rating: 4.4 (26))

At the bottom, there is a pagination bar showing page 1 of 5633, with a right arrow.

Symbols on diagrams

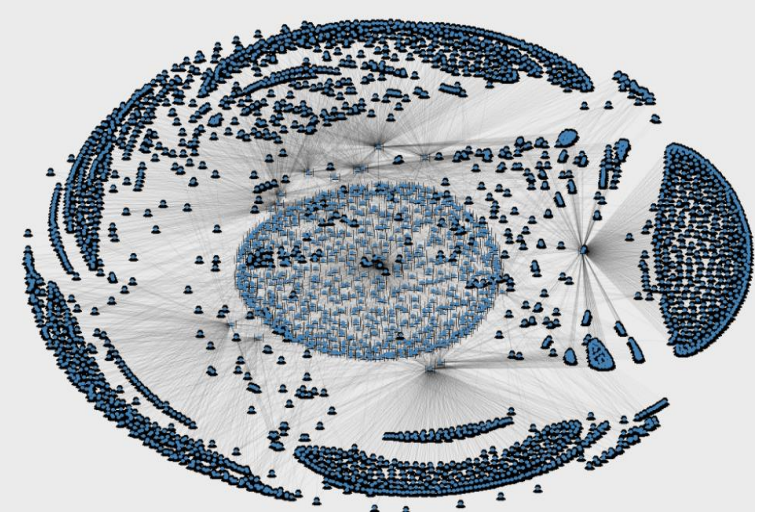
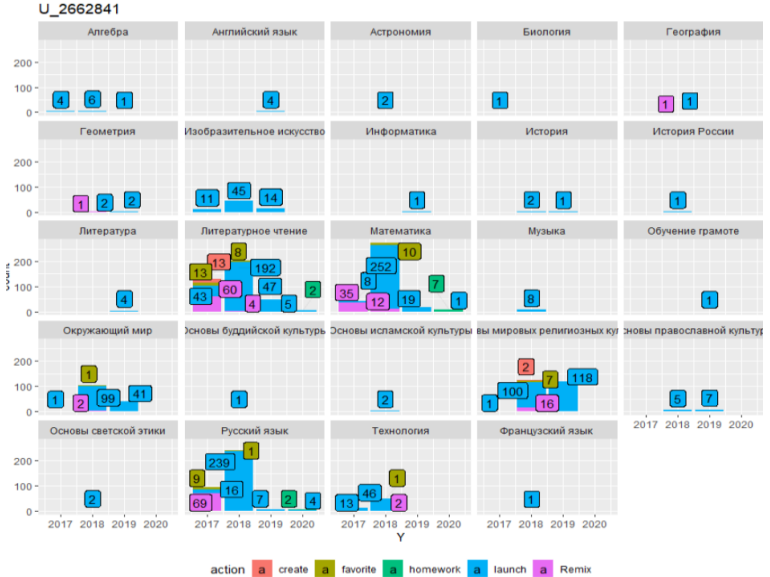
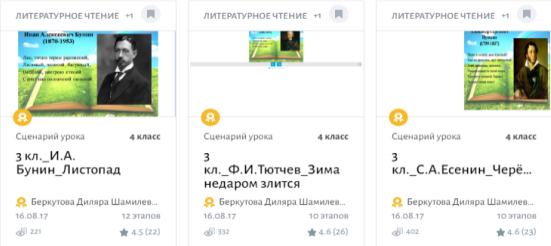
- User
- Scenario
- Action
- Create
- View
- Remix
- Launch during lesson
- Add to favorites
- Embed in homework
- Simultaneous actions



Full history of actions by the participants is logged, the log is available for analysis of actions of any participant and variation of each object. The logged history can be presented as a record containing the following mandatory elements:

1. Actor (agent) of the activities.
2. Object of the activities: text, scheme, presentation, lesson scenario, etc.
3. Type of activities: action applied by the subject to the object.
4. 4. Time of activities: record when the action was performed.

Teacher profile → Actions → Relationship



Can we filter out from the huge variety of agents, objects and about 40 millions actions (38,652,291) a network structure that will accurately reflect the community in which the participants are interconnected?

Filtering procedure for network fractions (tables)

Table 1. The table contains all the records about the actions that the participants take on the published lesson scripts

A tibble: 38,652,291 x 7

Table 2. The first table was cleared of actions for which it was impossible to establish the authors' affiliation to schools or the affiliation of lesson scripts to academic subjects. In addition, we removed the actions of users to view scenarios, assuming that such actions cannot lead to the formation of connections between users.

A tibble: 12,654,402 x 7

Table 3

For the third table, we filtered from the second table only the actions of the teachers who created and published lesson scripts.

A tibble: 3,003,736 x 7

Filtering procedure for network fractions (graphs)

Graph 1. Bipartite graph (users & learning scripts)

Graph 2. Unipartite graph (users)

A tbl_graph: 8355 nodes and 2633221 edges

A directed multigraph with 1 component

```
activate(edges) %>%  
filter(action == "Remix") %>%  
filter(edge_is_mutual()) %>%  
activate(nodes) %>%  
filter(!node_is_isolated())
```

Graph 3 Fraction of users reciprocally copying learning scenarios from each other

- # A tbl_graph: 1552 nodes and 21349 edges
- # A directed multigraph with 145 components

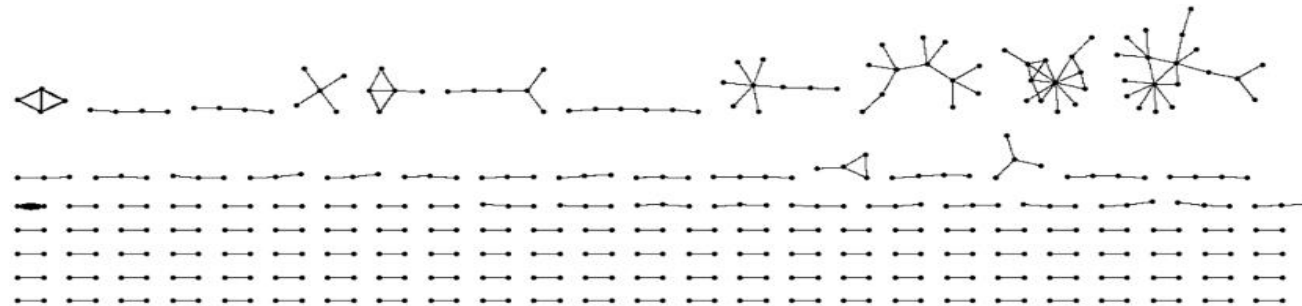
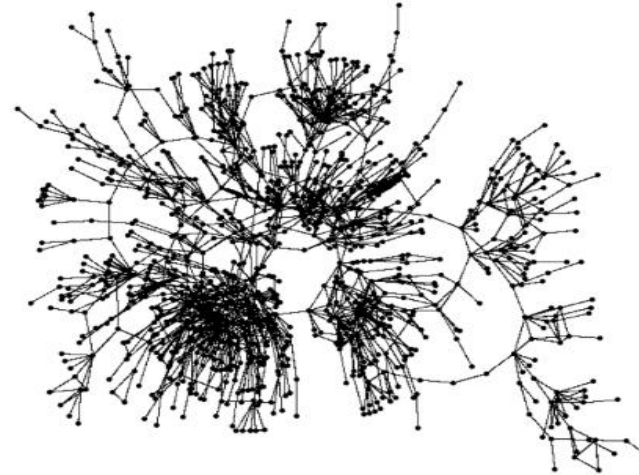
The teacher Boris copied the script from the teacher Anna.

Some time later, the teacher Anna copied the script from the teacher Boris. This is the principle of reciprocal copying.

Fraction of users reciprocally copying learning scenarios

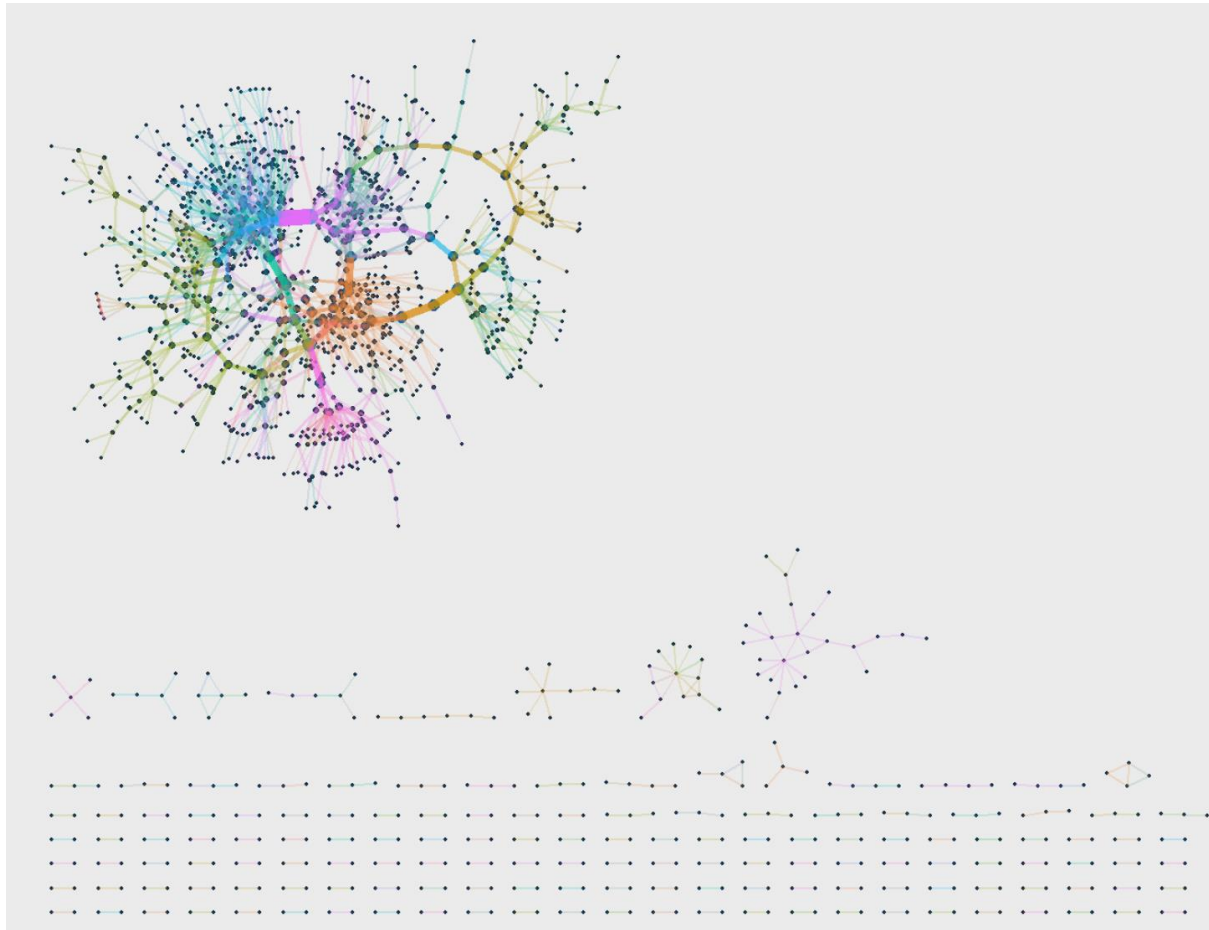
- The giant component contains 1174 nodes and 17928 links, while the remaining 144 components have only 378 nodes and 3421 links.

```
activate(nodes) %>%  
filter(group_components() == 1)  
# A tbl_graph: 1174 nodes and 17928 edges  
# A directed multigraph with 1 component
```



Stories of key-players on the bridges

```
%>%
activate(edges) %>%
  filter(!edge_is_multiple()) %>%
  convert(to_undirected) %>%
  activate(nodes) %>%
  mutate(c_betw =
centrality_betweenness()) %>%
  activate(edges) %>%
  mutate(edge_between =
centrality_edge_betweenness()) %>%
  activate(nodes) %>%
  ggraph(layout = 'stress') +
  geom_node_point(aes(size = c_betw,
colour = c_betw, shape = '21')) +
  geom_edge_link0(aes(alpha =
edge_between, width = edge_between,
color = subject)) +
  theme(legend.position = 'none')
```



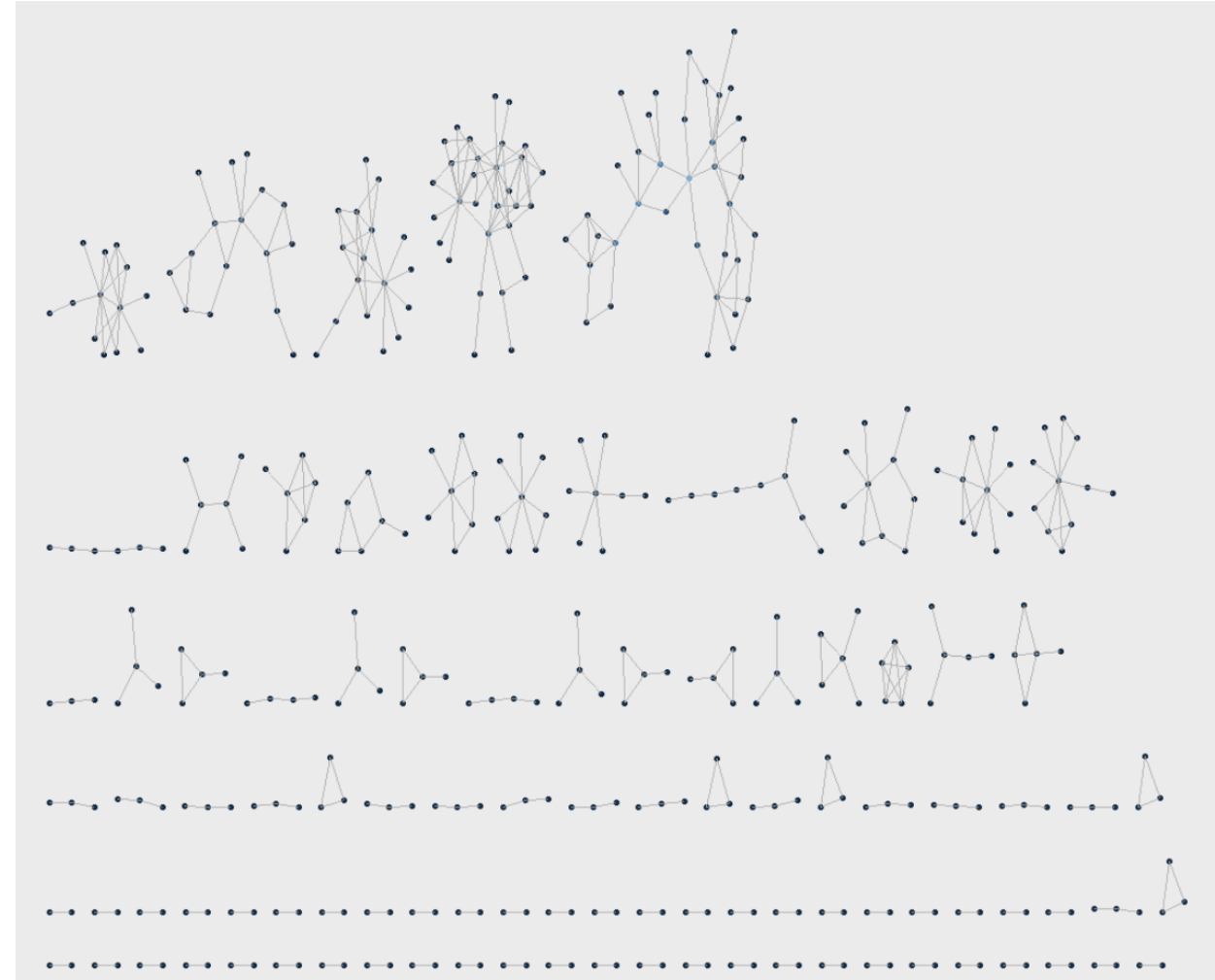
See how the language **R** and package **tidygraph** helps us tell the story of teacher relationships

Stories about groups of teachers working in the same schools

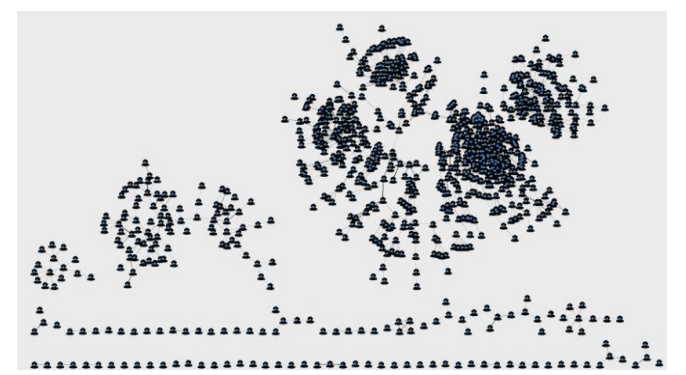
```
activate(edges) %>%  
  filter(school_creator == school_user ) %>%  
  activate(nodes) %>%  
  filter(!node_is_isolated())
```

A tbl_graph: 419 nodes and 7159 edges

A directed multigraph with 99 components



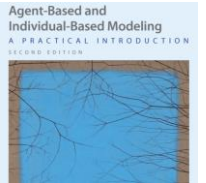
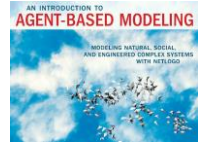
Agent Based Modelling



- Generative Science Approach
- “If you didn’t grow it, you didn’t explain it” (Joshua Epstein 1999).
You can explain how something emerge only if you grow it.
- Can we grow an artificial community of teachers in which 75% of the users will be part of a giant component?

Agent Based Modelling (NetLogo Books)

- Wilensky U., Rand W. An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo. MIT Press, 2015.
- Railsback S.F., Grimm V. Agent-Based and Individual-Based Modeling: A Practical Introduction, Second Edition. Princeton University Press, 2019. 359 p.
- Romanowska I., Wren C. D., Crabtree S. A. Agent-Based Modeling for Archaeology: Simulating the Complexity of Societies. Santa Fe: Santa Fe Institute Press, 2021. 442 c.



We chose NetLogo language because most of the researchers speak it. We chose NetLogo language because there are several huge model repositories. And we have chosen some of the most famous models of the emergence of flocks and teams.

NetLogo Libraries

NetLogo Models Library | Welcome to the Modeling Comm

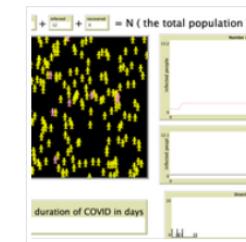
CoMSES Net Computational Mod

CoMSES NETWORK | OpenABM | WEST BIG DATA INNOVATION HUB

- Biology
 - [Ant Lines](#)
 - [Ants](#)
 - [Autumn](#)
 - [BeeSmart Hive Finding](#)
 - [Blood Sugar Regulation](#)
 - CRISPR
 - [CRISPR Bacterium LevelSpace](#)
 - [CRISPR Bacterium](#)
 - [CRISPR Ecosystem LevelSpace](#)
 - [CRISPR Ecosystem](#)
 - [Daisyworld](#)
 - [Disease Solo](#)
 - Evolution
 - [Anisogamy](#)
 - [Bacterial Infection](#)
 - [Bug Hunt Camouflage](#)
 - [Bug Hunt Speeds](#)
 - [Echo](#)
 - Genetic Drift
 - [GenDrift P.global](#)
 - [GenDrift P.local](#)
 - [GenDrift T.interact](#)
 - [GenDrift T.reproduce](#)
 - [Mammoths](#)
 - [Mimicry](#)
 - [Peppered Moths](#)
 - [Sex Ratio Equilibrium](#)
 - [Sunflower Biomorphs](#)
 - [Vision Evolution](#)
 - [Wolf Sheep Stride Inheritance](#)
 - [Fairy Circles](#)
 - [Fireflies](#)
 - [Flocking Vee Formations](#)
 - [Flocking](#)
 - [Fur](#)
 - [HIV](#)
 - [Heatbugs](#)
 - [Honeycomb](#)

Most Downloaded Models (in the past 2 weeks)

	SEIR-Model-Base-Seasonal Downloaded 10 times in the past 2 weeks
	SEIR-Model-Antivirals Downloaded 10 times in the past 2 weeks
	Pong HubNet Downloaded 5 times in the past 2 weeks
	Food Chain with 10% Energy Rule Downloaded 5 times in the past 2 weeks
	SEIR-Model-Vaccination-Seasonal Downloaded 5 times in the past 2 weeks
	heredity--pumpkin contest Downloaded 4 times in the past 2 weeks
	COVID-19 VIRUS SPREAD Downloaded 4 times in the past 2 weeks
	SEIR-Model-Isolation Downloaded 3 times in the past 2 weeks
	Traffic Model on google map Downloaded 3 times in the past 2 weeks
	Quick hull demo Downloaded 3 times in the past 2 weeks



Introductory SIR Model

Kit Martin | Amber Cesare | Matthew Johnson | Published Tue Sep 28 15:20:46 2021

This is a basic Susceptible, Infected, Recovered (SIR) model. This model explores the spread of disease in a space. In particular, it explores how changing assumptions about the number of susceptible people, starting number of infected people, as well as the disease's infection probability, and average duration of infection. The model shows that the interactions of agents can drastically affect the results of the model.

We used it in our course on COVID-19: <https://www.csats.psu.edu/science-of-covid19>

COVID-19 | NetLogo



Flocking

to flock

find-flockmates

if any? flockmates

[find-nearest-neighbor

ifelse distance nearest-neighbor <

minimum-separation

[separate]

[align

cohere]

end

The screenshot displays the NetLogo interface for a flocking simulation. On the left, there are several sliders for parameters: population (set to 250), vision (3.0 patches), minimum-separation (1.00 patches), max-align-turn (5.00 degrees), max-cohere-turn (3.00 degrees), and max-separate-turn (2.00 degrees). Below these are 'setup' and 'go' buttons. The central window shows a black background with numerous yellow triangles representing birds, forming a loose flock. On the right, the 'Experiment' dialog box is open, showing the following configuration:

- Experiment name: Baseline
- Vary variables as follows (note brackets and quotation marks):

```
[max-cohere-turn ]  
[max-separate-turn 1.5]  
[vision 3]  
[minimum-separation 1]  
[population 500]
```
- Repetitions: 10
- Run combinations in sequential order: checked
- Measure runs using these reporters:

```
count turtles with [any? flockmates]  
mean [count flockmates] of turtles  
mean [min [distance myself] of other turtles] of turtles  
standard-deviation [heading] of turtles
```
- Measure runs at every step: checked
- Setup commands: setup
- Go commands: go
- Time limit: 500

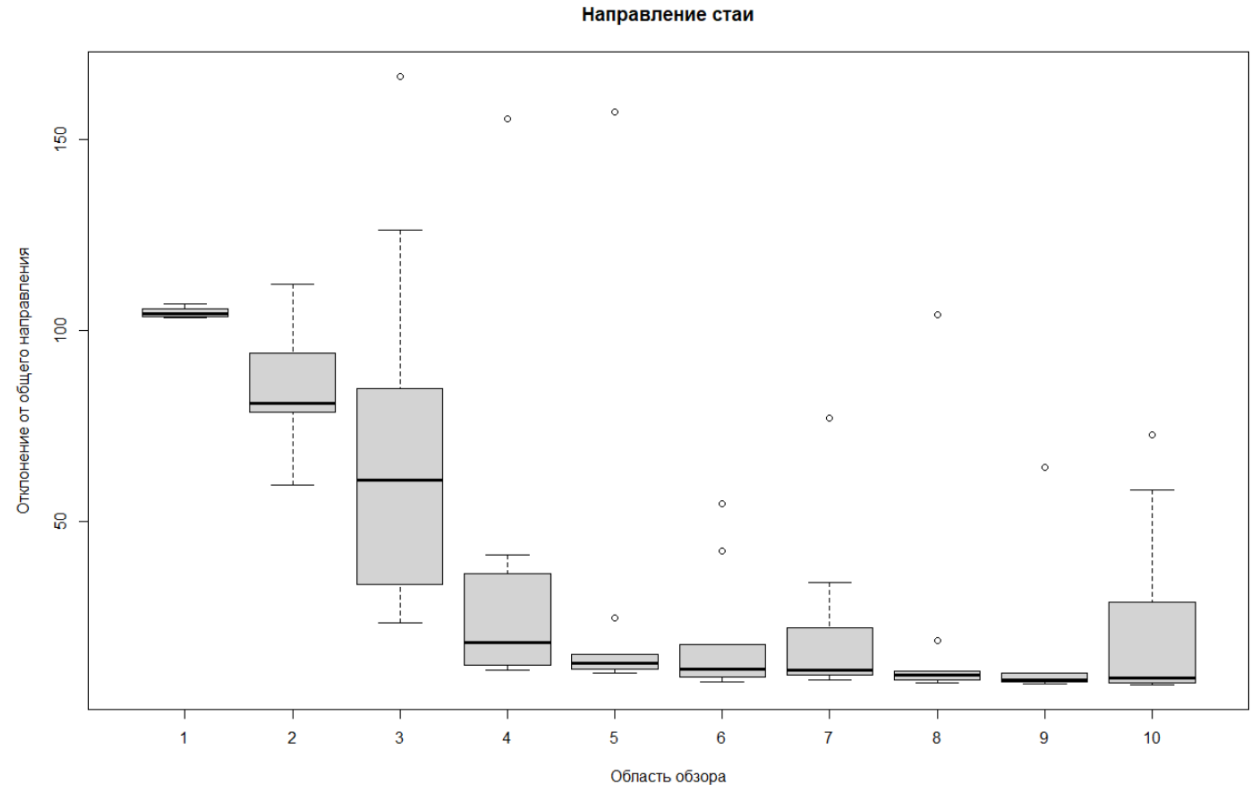
At the bottom, there is a 'BehaviorSpace' window showing a list of experiments: 'experiment (25 runs)' and 'baseline (10 runs)'. The 'baseline' experiment is selected.

How the variable VISION affects the rate of formation of the flock? **BehaviorSpace**

Flocking Experiments

BehaviorSpace

- [*"max-cohere-turn" 2*]
- [*"max-separate-turn" 2*]
- [*"vision" 1 2 3 4 5*]
- [*"minimum-separation" 1*]
- [*"population" 400*]
- [*"max-align-turn" 4*]



Deviation from average heading / Vision

Team Assembly

repeat team-size

*[ifelse random-float 100.0 >= **p***

[make-newcomer

set new-team-member newcomer]

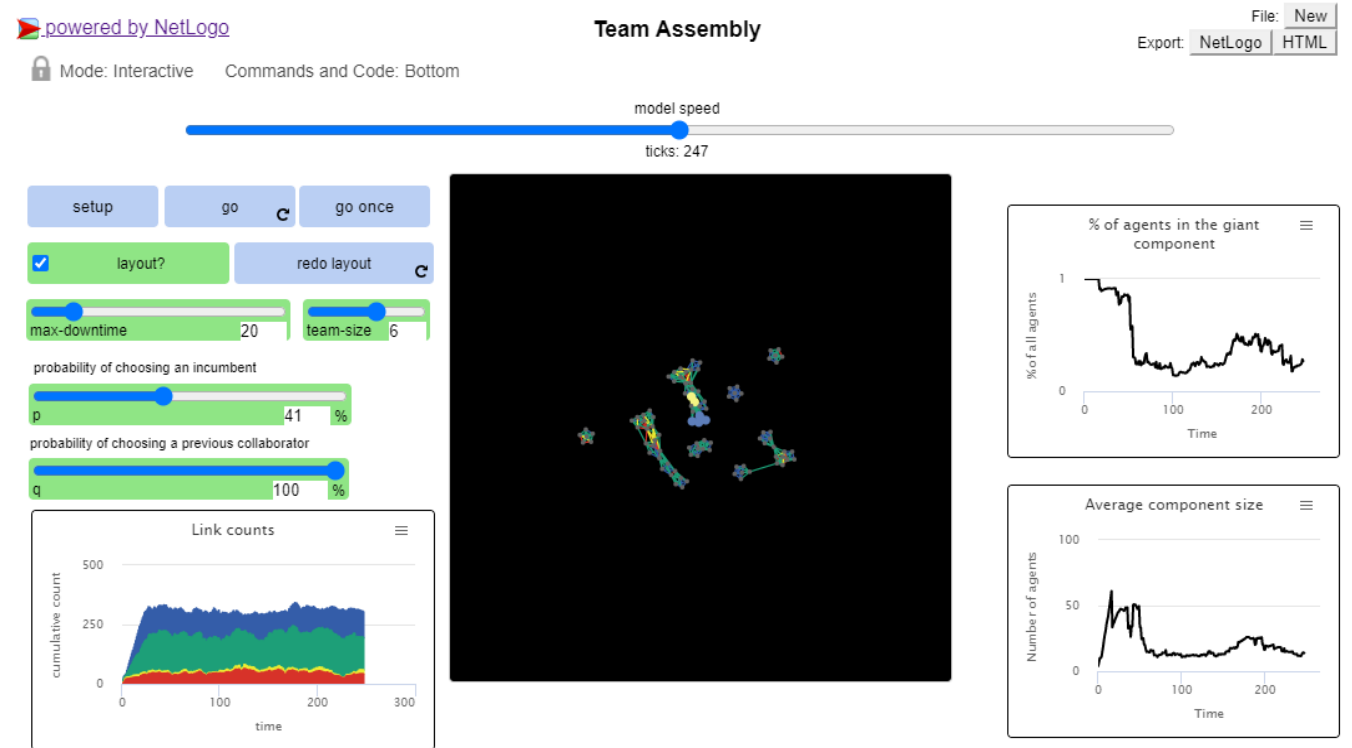
*ifelse random-float 100.0 < **q***

*and any? (turtles with [in-team? and
(any? link-neighbors with [not in-team?]))]*

[set new-team-member one-of turtles with

[not in-team? and (any? link-neighbors with [in-team?])]

[set new-team-member one-of turtles with [not in-team?]]



Team Assembly Experiments

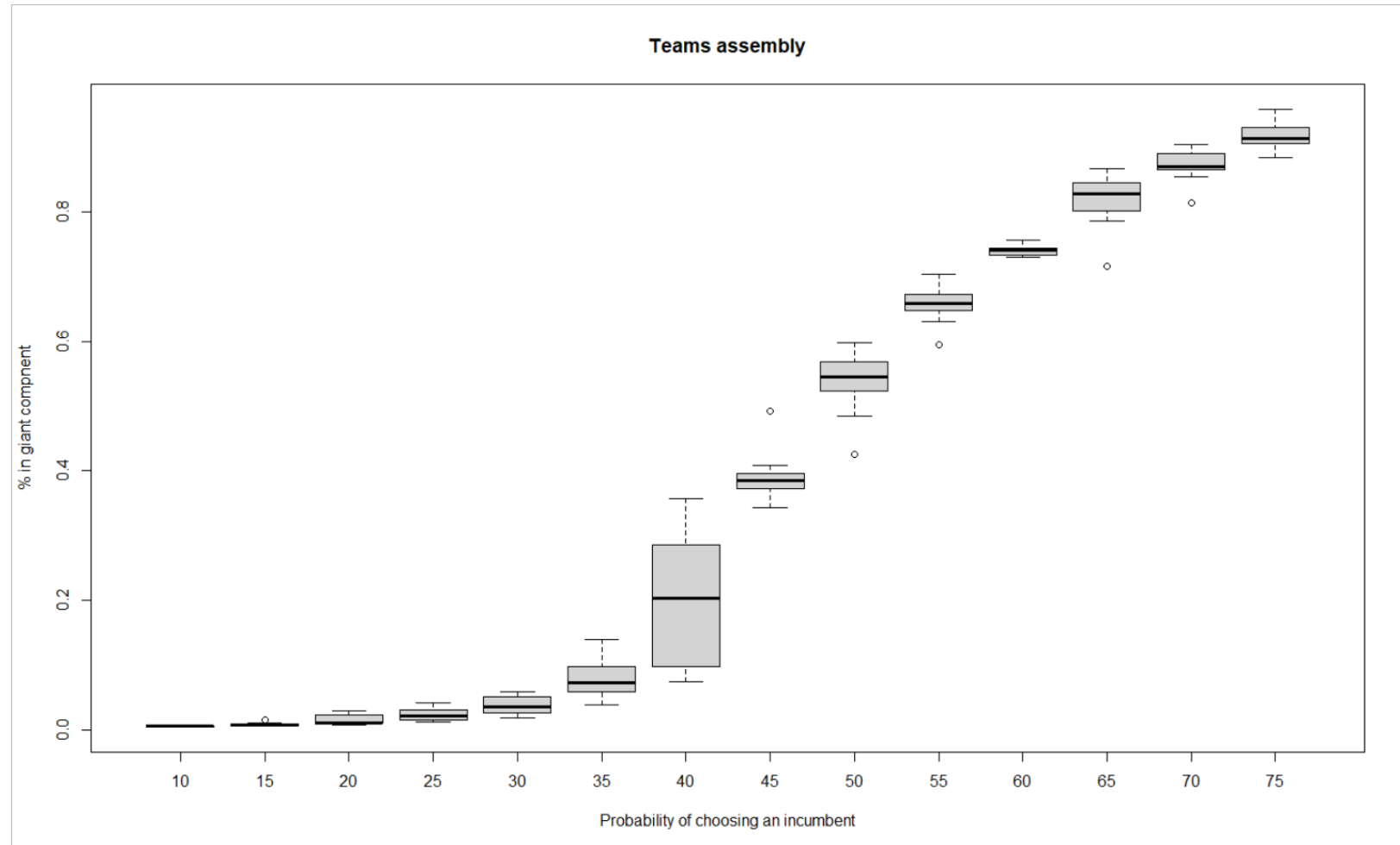
BehaviorSpace

["max-downtime" 800]

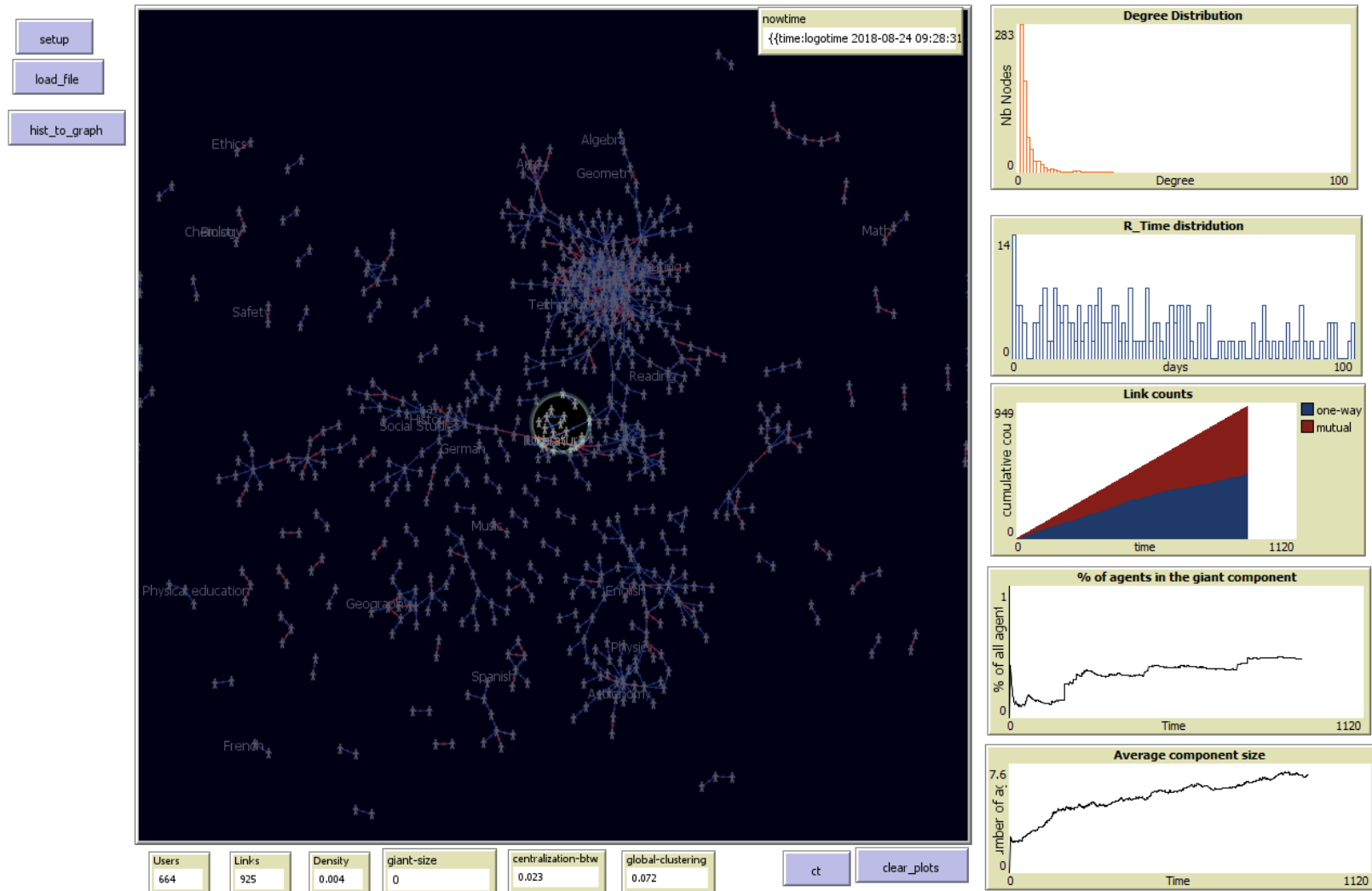
["team-size" 2]

["p" [10 5 75]]

["q" 52]

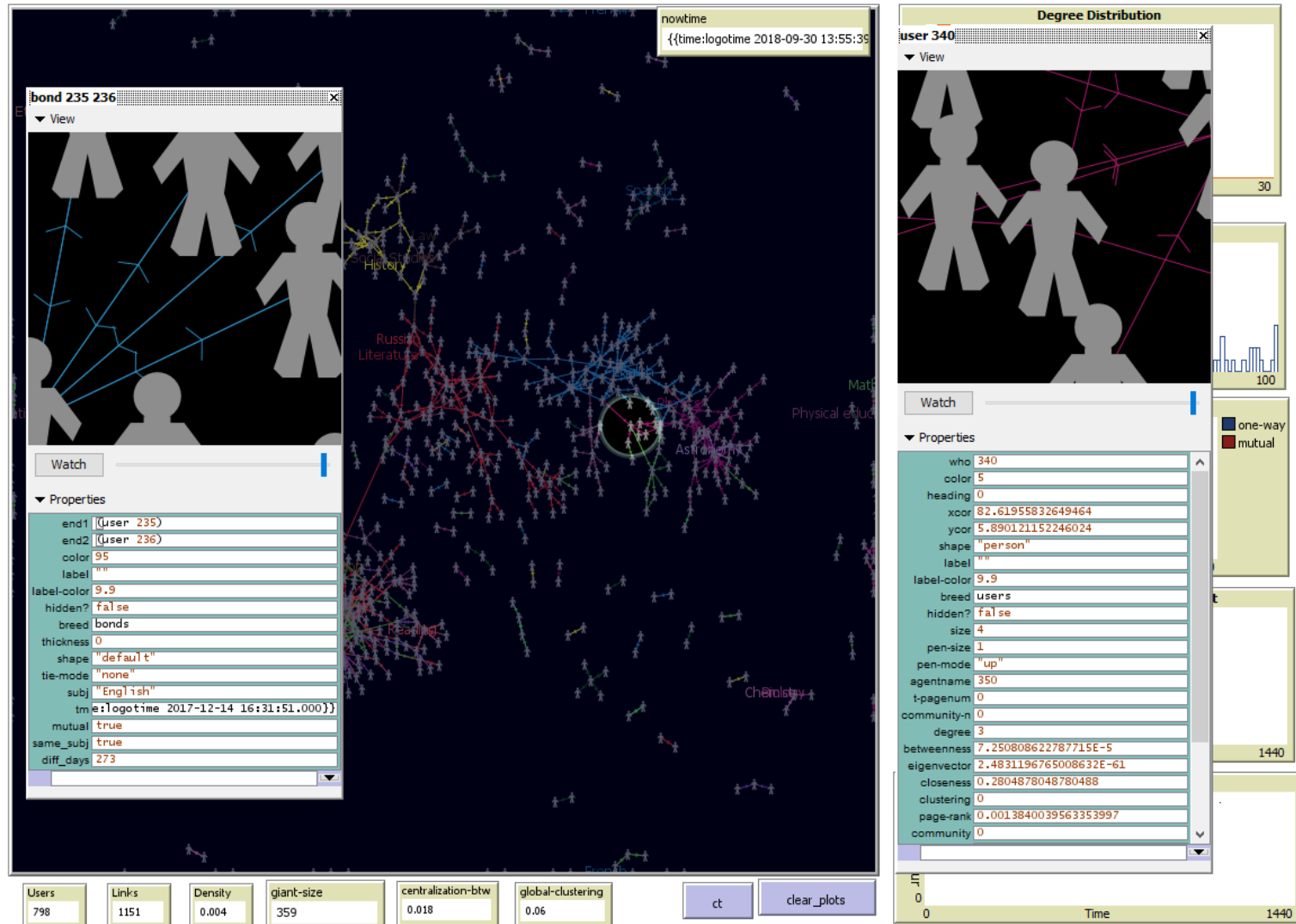


Simulation of reciprocal network formation



Story about actors and links

- Information about everyone



Results

- We think of the MES community as a community of scientists. This allows us to use the theoretical framework and research methods developed for team science.
- The results obtained from the analysis of the digital traces of the MES are the results of a scientific research. These results can be shared and these results should be replicated by other researchers.
- Netlogo Demo -> Now we go back to animated story of Moscow Electronic School