複雑系としての協調学習空間に対する数理分析の可能性

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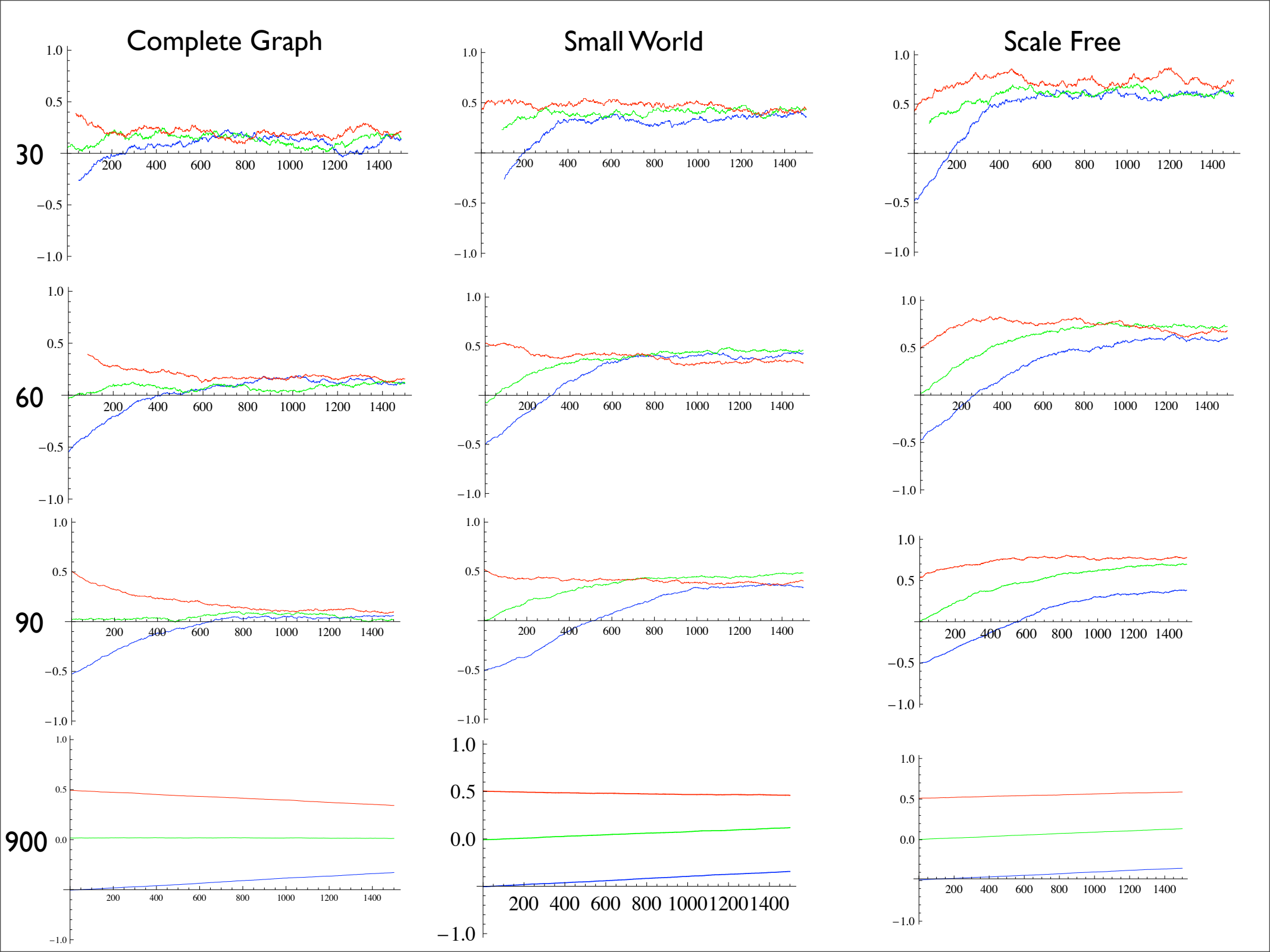
Finding Facts

- A multidisciplinary approach based on concepts from statistical physics, complex networks sciences is developed for the theoretical (scientific) description of collaborative learning processes.
- Using the emergence model, we find out that the network structure that is formed among learners in the classroom have much effect on the achievements reached in collaborative processes.


Complete Graph
Small World
Scale Free
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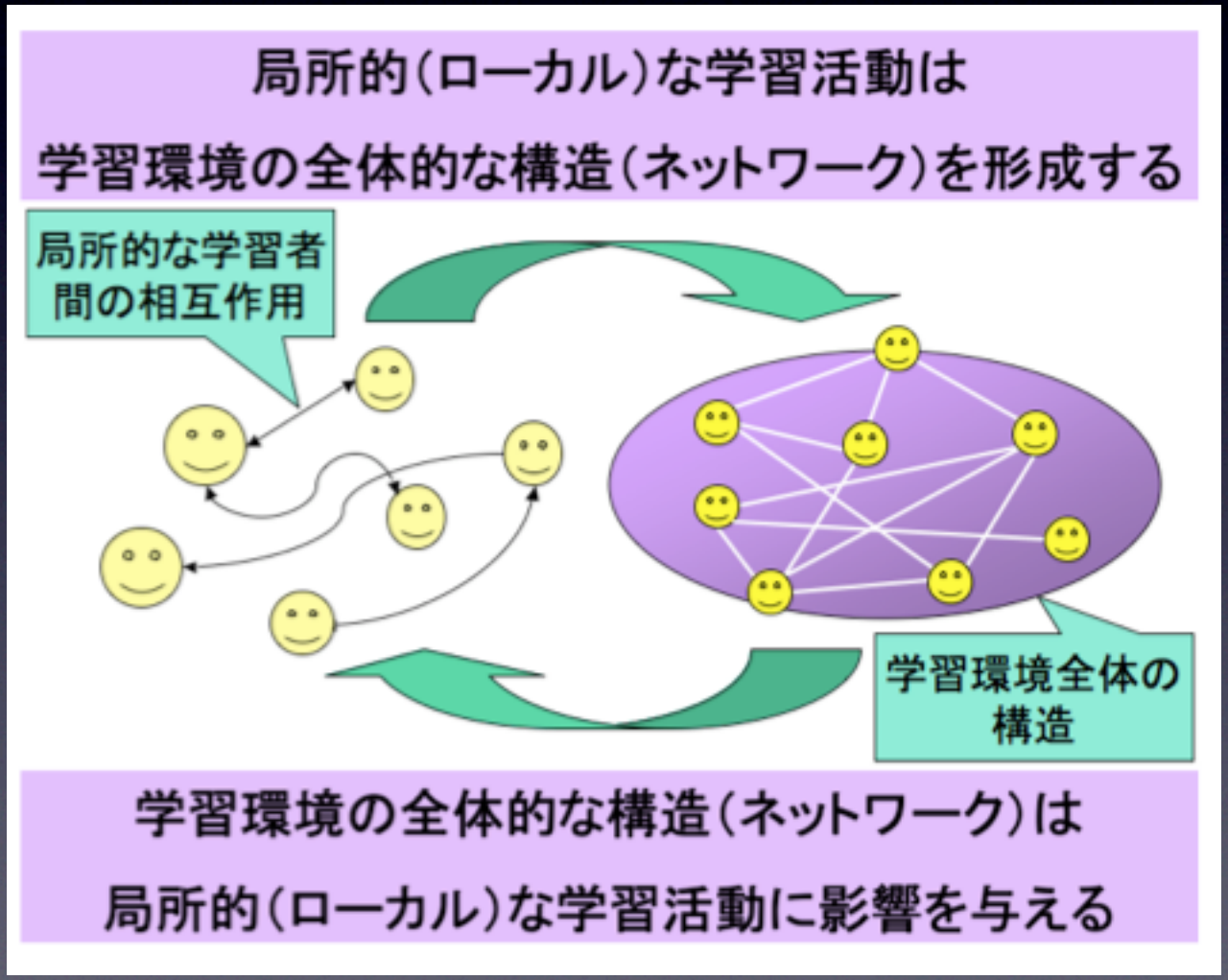
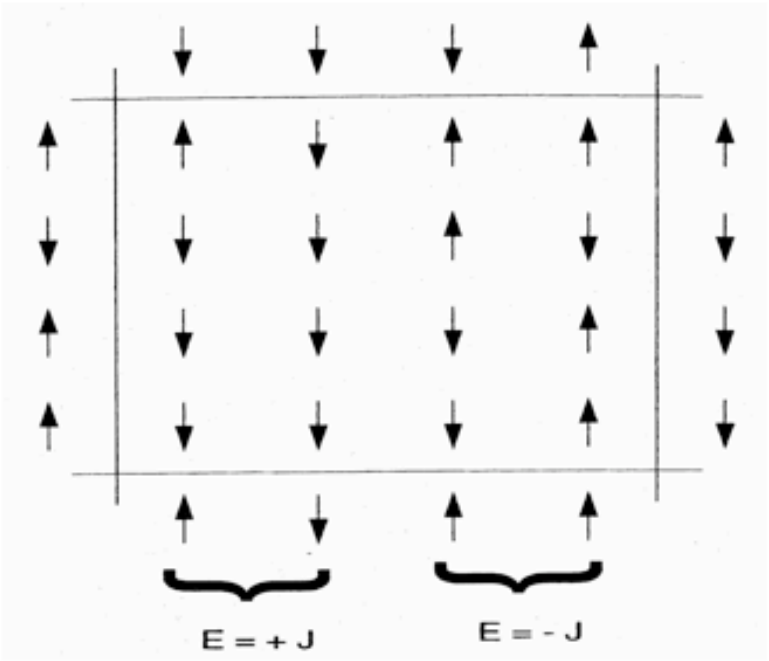
collaborative learning environment as a complex system



- Whereas initially complex-systems methods and perspective arose from the natural sciences, complexity, emergence, and micro- and macro- levels of description of phenomena are all highly relevant to research in the social sciences... Learning, too, we argue, can be construed as a complex phenomenon. (Abrahamson 2006)

- Despite of those successful applications of computer simulation in many areas of social sciences, educator and educational psychologist are traditionally quite skeptical and uncomfortable with the use of mathematical and computational techniques to describe education because they have argued that social situations are too complex to be formulated in a few equations. Consequently, there is very few research work done on the scientific modeling of the educational processes. (Yeung 2006)

Ising Model



The Ising Model assumes that each spin is able to point in the +z direction or the –z direction and that the i^{th} spin in the system has the value of $\pm s_i$. There are interactive forces between spins. The interaction is strongest between nearest neighboring spins, and the Ising Model assumes that the interaction between nearest neighbors is the *only* interaction in the system. It neglects the forces associated with spins further away. The energy of the system, with no external field, is then:

$$E = -J \sum s_i s_j$$

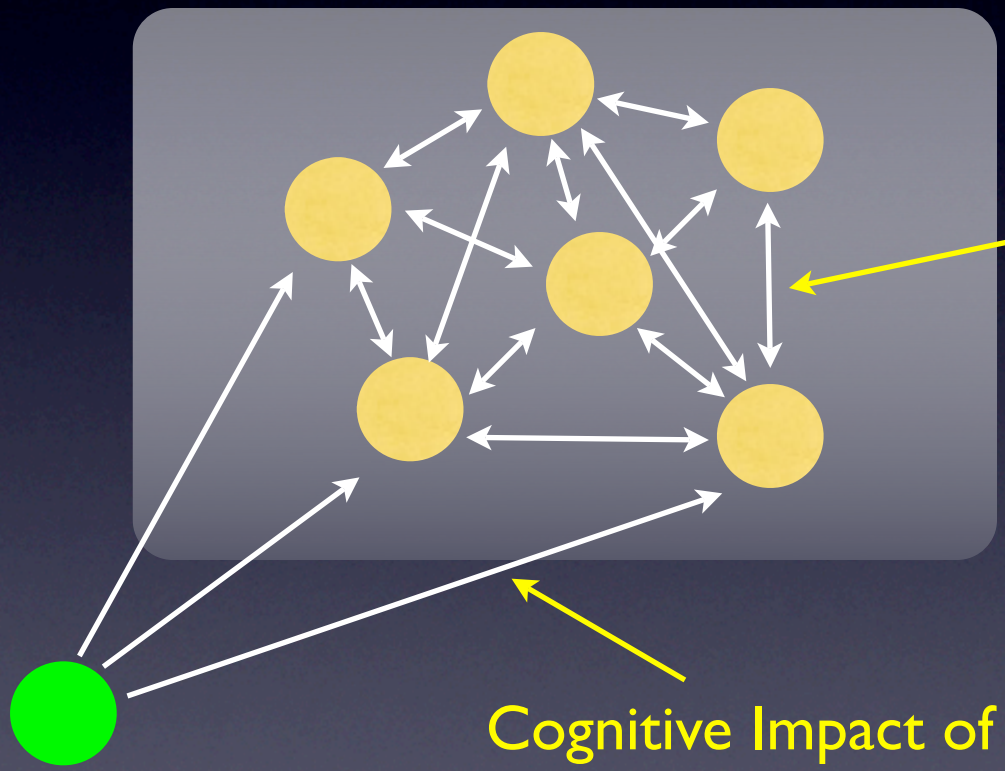
http://rutgersscholar.rutgers.edu/volume02/cowldevl/cowldevl.htm

a magnetization and a collaborative learning environment

Electron spin Si the ith atom	The ith learners knowledge Si(t) at time t
A magnet with N atoms	A class of N learners
External applied magnetic field H	Teachers influence or interaction with each student
Hamiltonian	The overall learning achievement is determined by 3 types of cognitive impact
The noise effect of the absolute temperature	The learning environment temperature (noise)

Y-y, Yeung, Scientific Modeling of Technology-Mediated Collaborative Learning Processes (2006)

Bordagna-Albano Model (2001)



Cognitive Impact of Student-Student Interaction Noise; disorder discussions, misunderstandings, lack of a well-organized participative, etc.

Cognitive Impact of Student-Other interaction (interactions with or learning from other materials or person) Noise; inappropriate selection of the bibliography, lack of attention, etc.

Cognitive Impact of Teacher-Student Interaction, Noise; disorder in the classroom, inappropriate teaching material, obscure explanations, etc

- the initial each student knowledge level is assumed to be randomly distributed $\sigma_i(t^0) \in (-1, 1)$
- learners is classified into 3 groups according to each initial knowledge level
- at time t, calculating cognitive impacts of teacher-student, student-student, student-other interaction, respectively

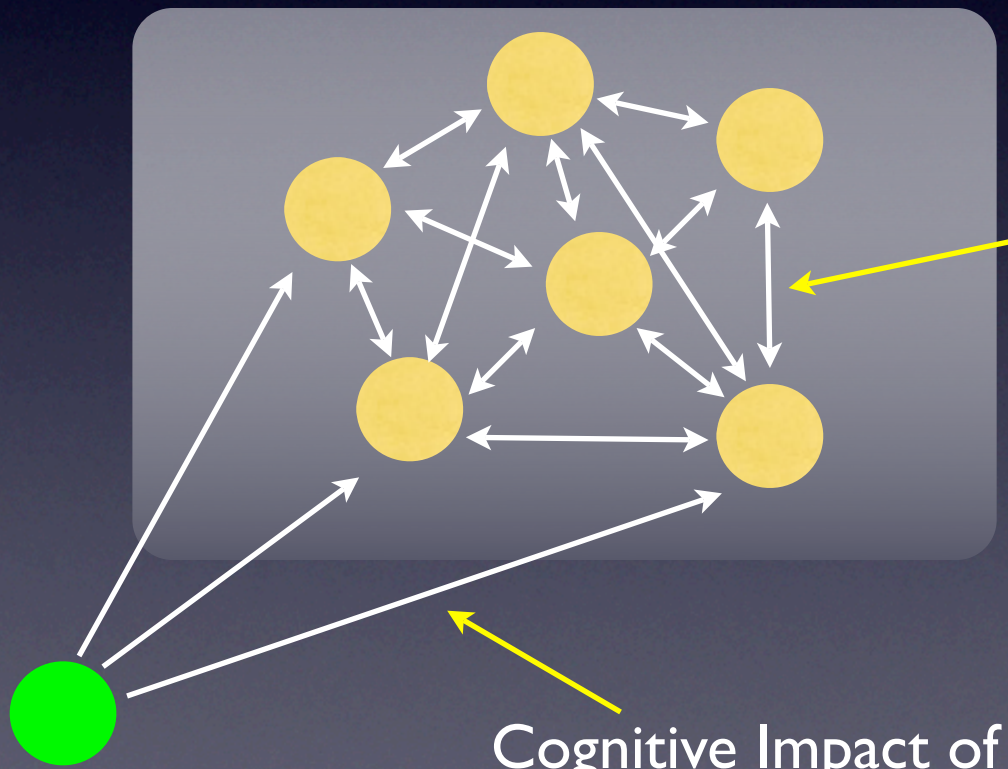
$$C_i^{SS}(t) := \sum_{j,j\neq i}^{N} [\alpha_{ij}(t)(1 - \sigma_i(t)\sigma_j(t)) - \beta_{ij}(t)(1 + \sigma_i(t)\sigma_j(t))] \operatorname{sign}(\sigma_j(t)/\sigma_T)$$

$$where \;\; \alpha_{ij}(t) := \alpha_{ij}^0(\sigma_T + \sigma_j(t)) \; and \; \beta_{ij}(t) := \beta_{ij}^0(\sigma_T + \sigma_j(t))$$

$$\sigma_i(t+\Delta t) = \sigma_i(t) + \Delta\sigma \text{ with a probability of } p_i = \frac{\tau_i}{1+\tau_i}$$

$$\sigma_i(t+\Delta t) = \sigma_i(t) - \Delta\sigma \text{ with a probability of } 1 - p_i$$

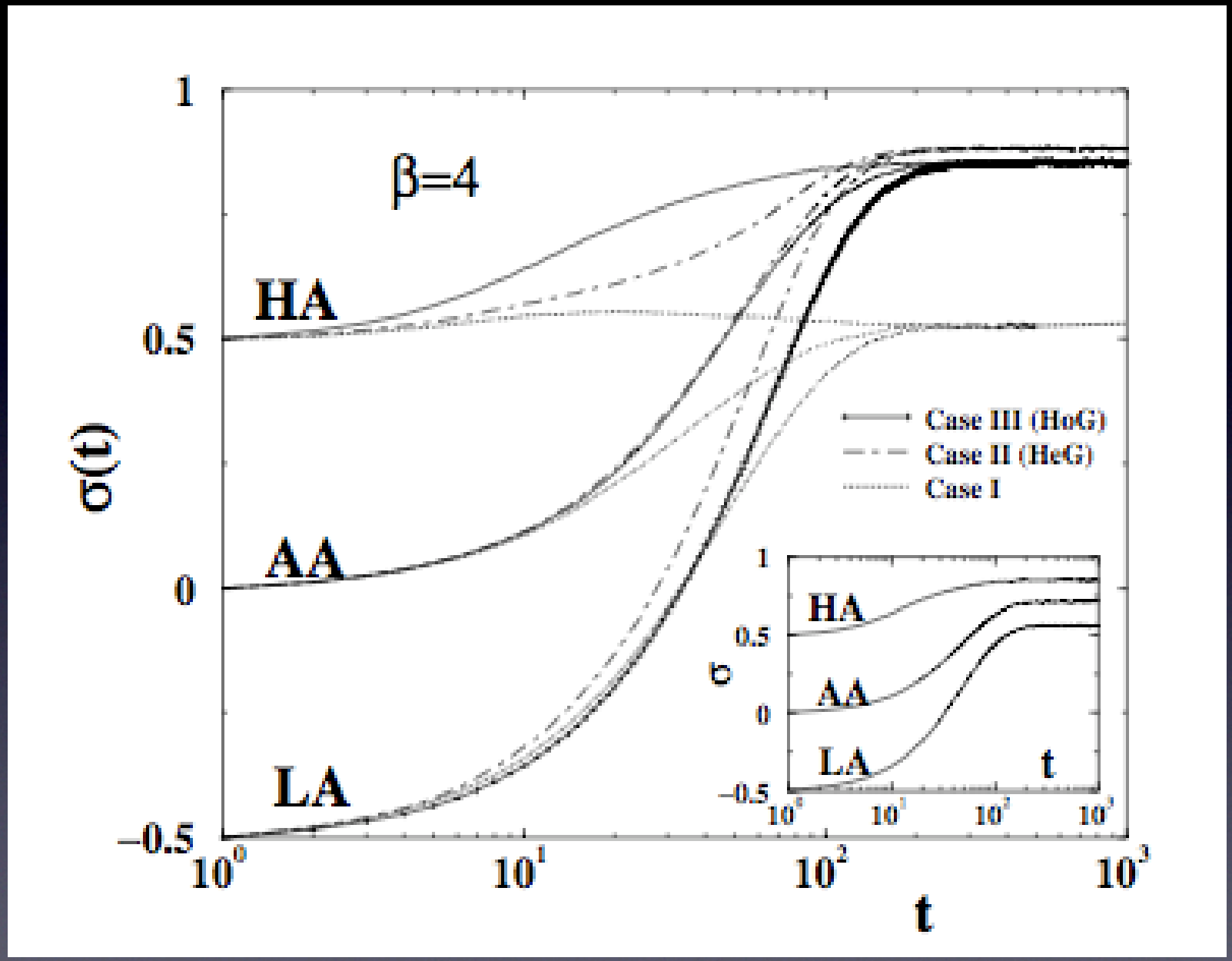
$$\text{where } \tau_i = \exp[\beta_{TS} C_i^{TS}(t) + \beta_{SS} C_i^{SS}(t) + \beta_{TO} C_i^{TO}(t)]$$



Cognitive Impact of Student-Student Interaction and Noise

Cognitive Impact of Student-Other interaction (interactions with or learning from other materials or person) and Noise

Cognitive Impact of Teacher-Student Interaction and Noise


β=4
HA
AA
LA
σ(t)
t
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10^0
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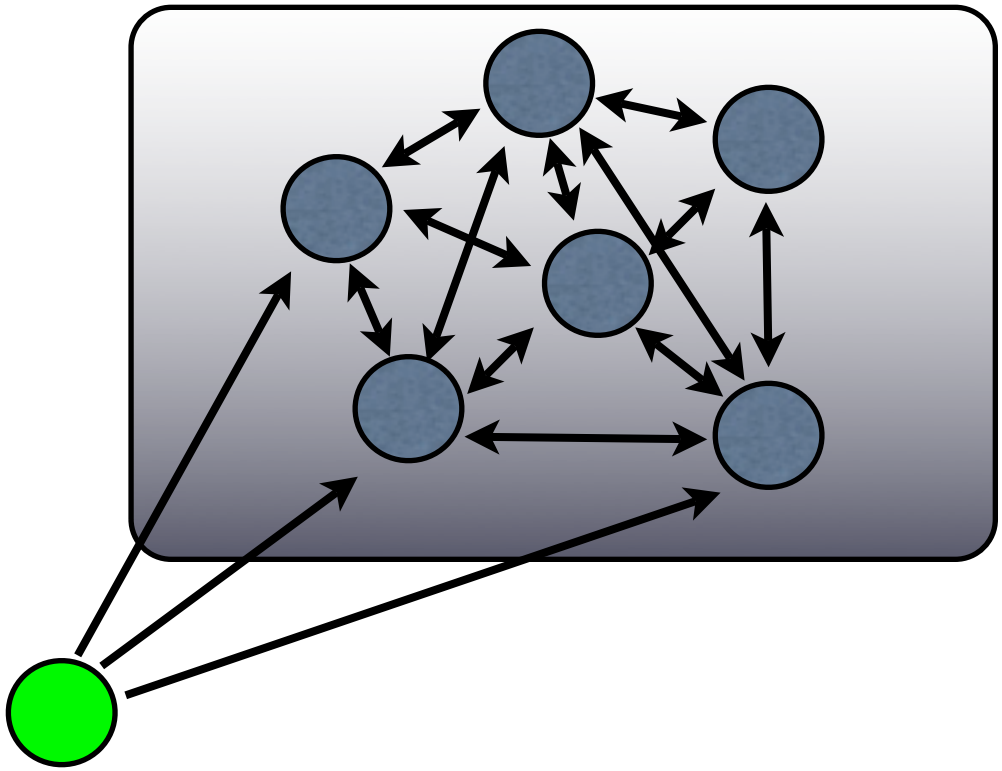
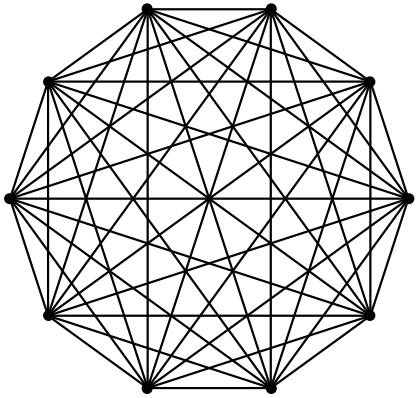
10^3
Case III (HoG)
Case II (HeG)
Case I
σ
t

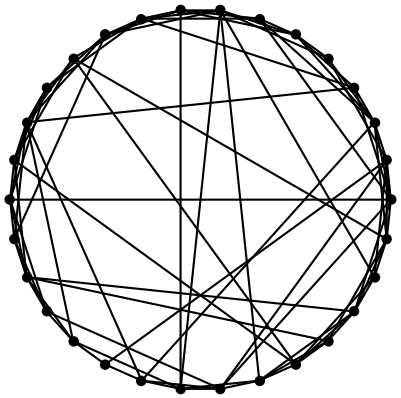
Our Model

- Based on Bordagna-Albano Model
- Introducing Complex Networks Structure

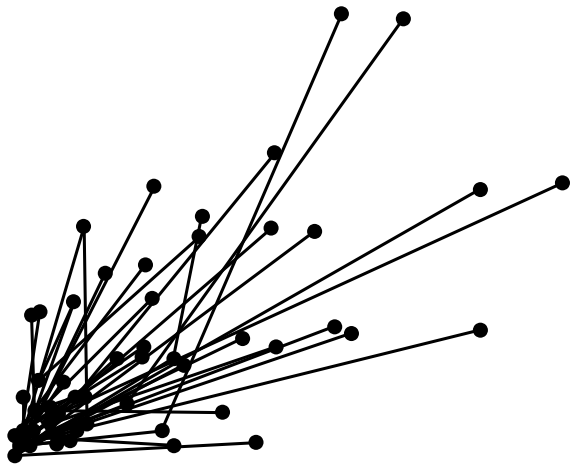




Complete Graph

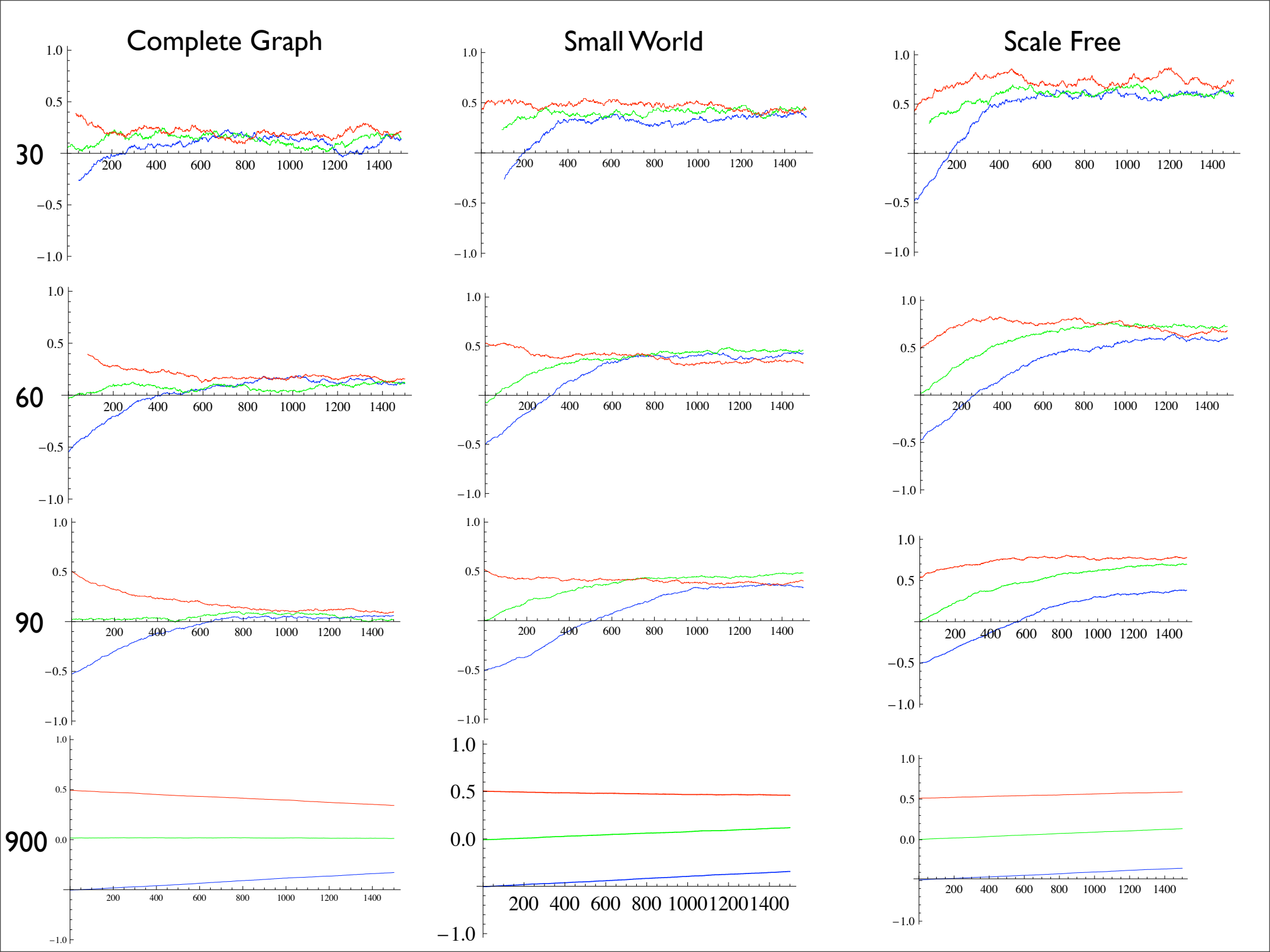


Small World (Watts-Strogatz)



Scale Free (Barabasi-Albert)

Results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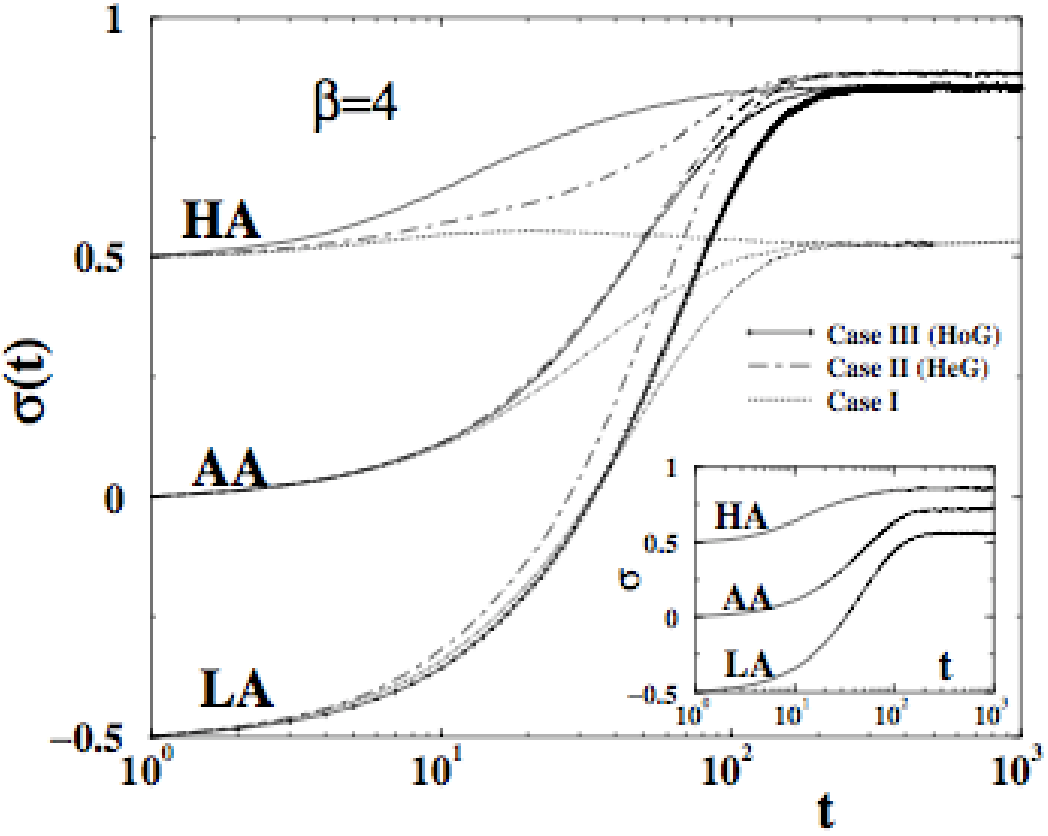
Why ?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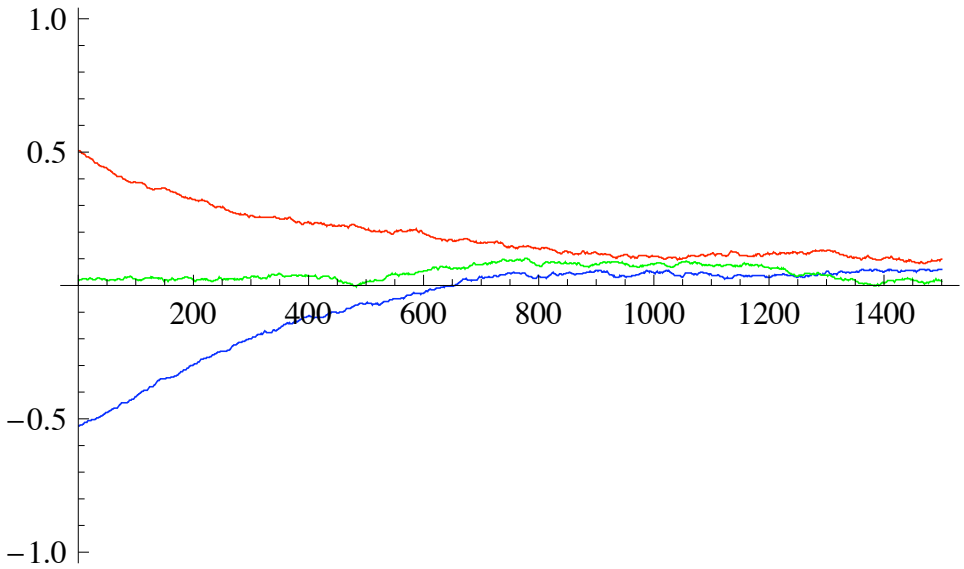
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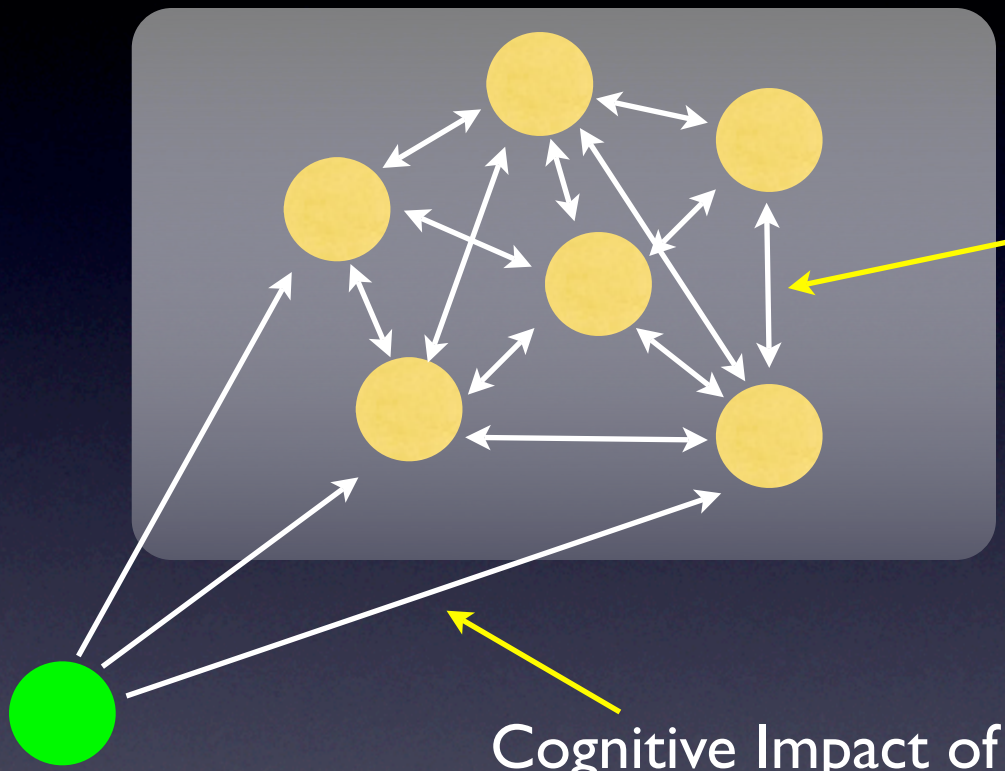

Cognitive Impact of
Student-Student Interaction
and Noise

Cognitive Impact of
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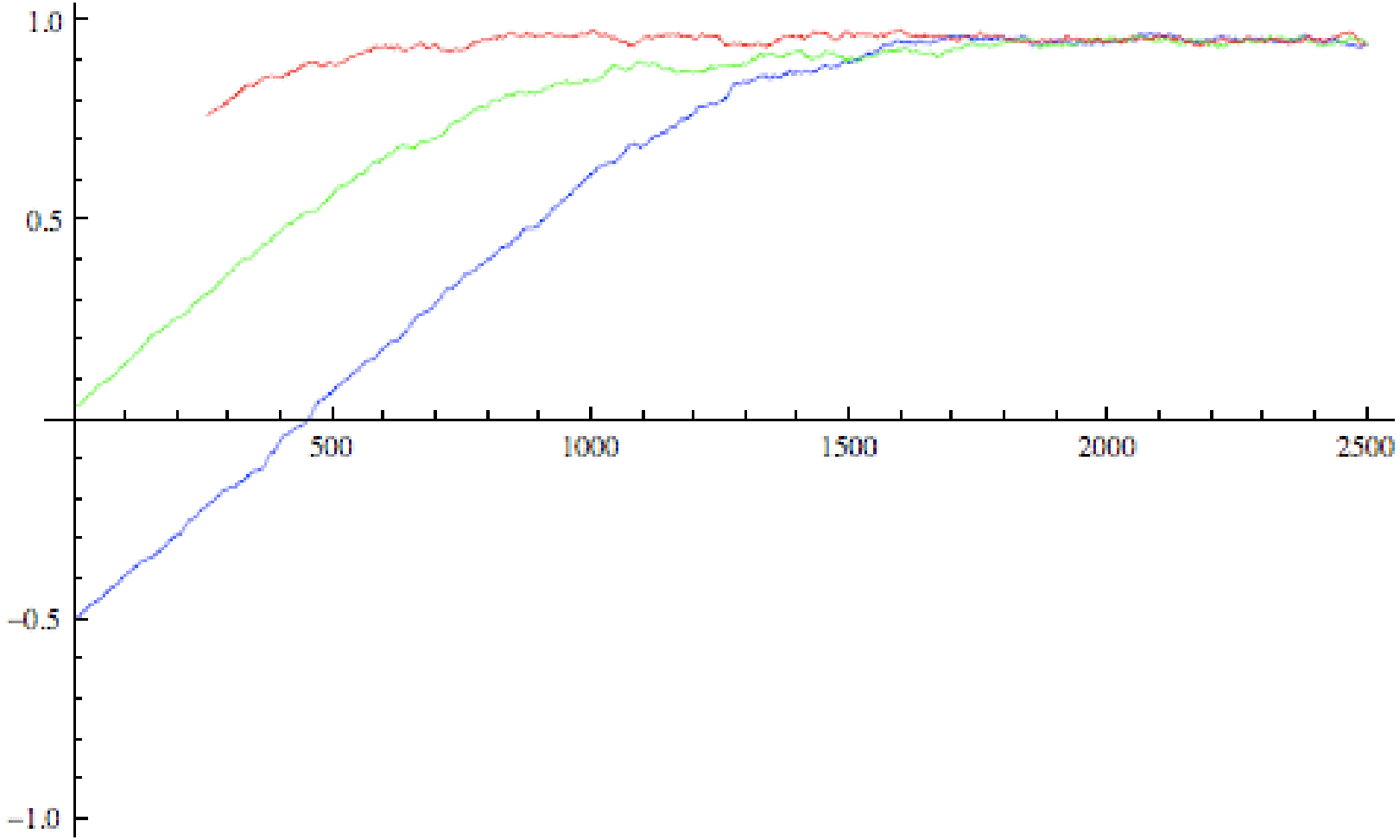
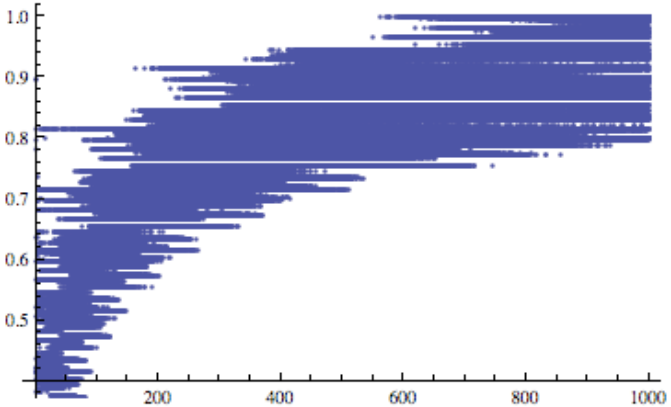
(interactions with or learning from
other materials or person)
and ~~Noise~~

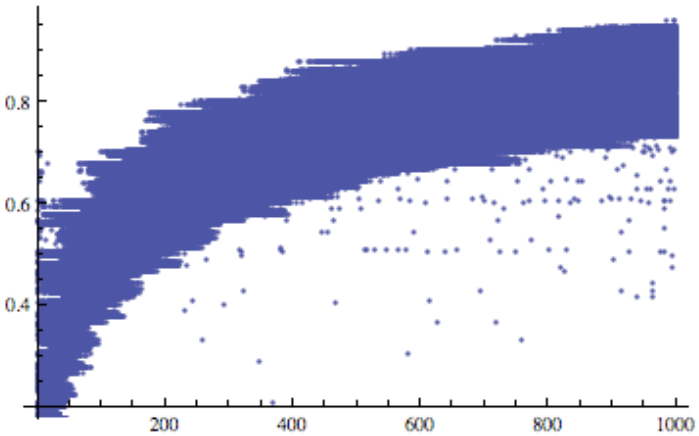
Cognitive Impact of
Teacher-Student Interaction and Noise

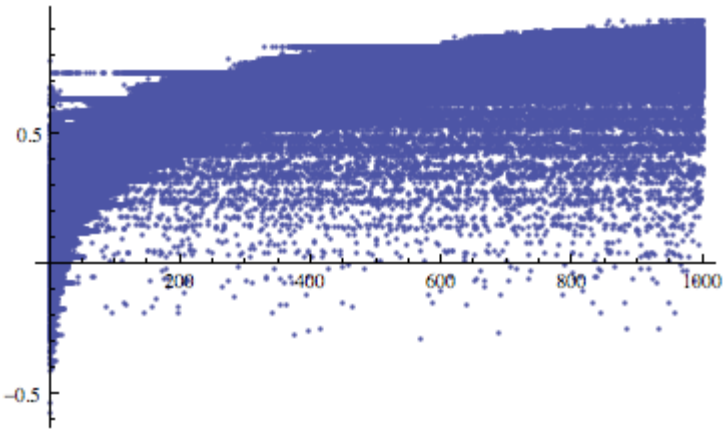
Complete Graph (βso=10,000)



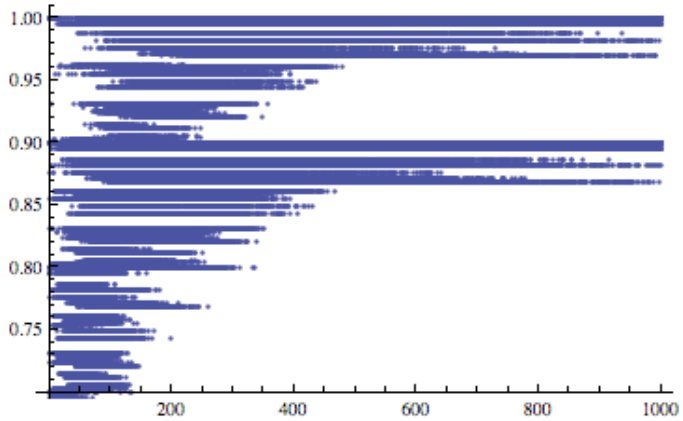
βso Complete Graph

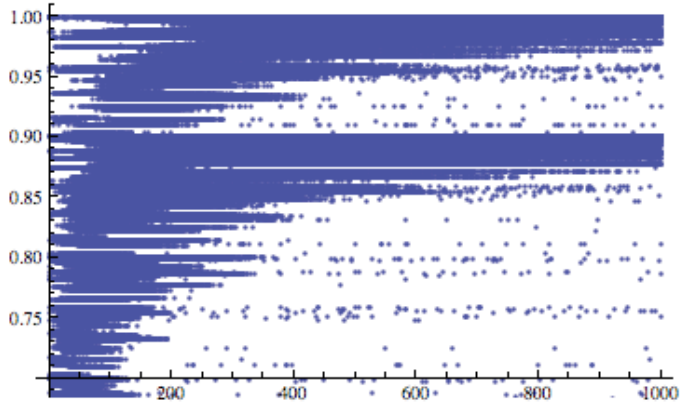






βso Small World



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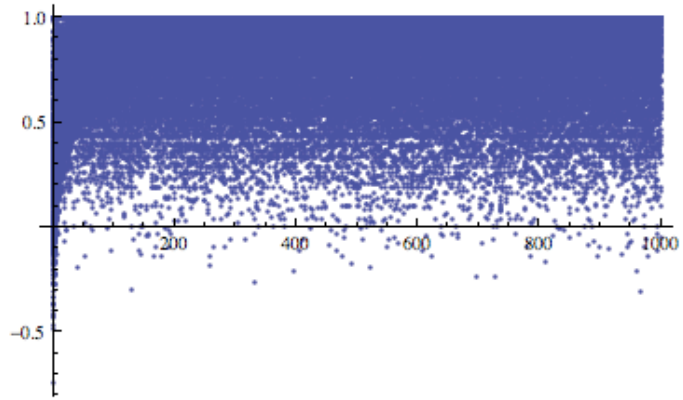
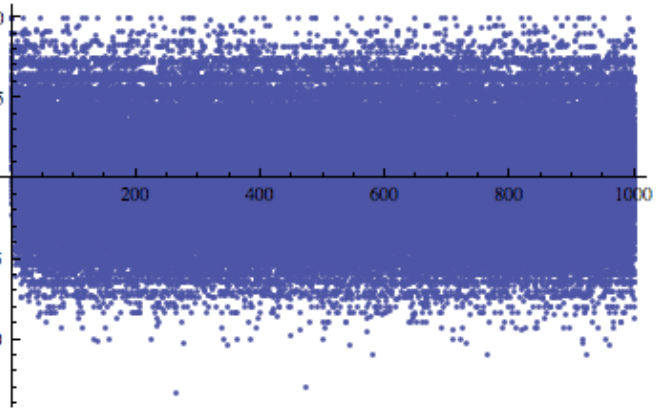


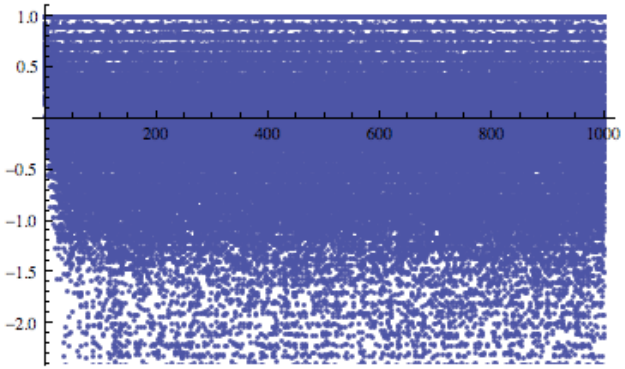
βss Complete Graph

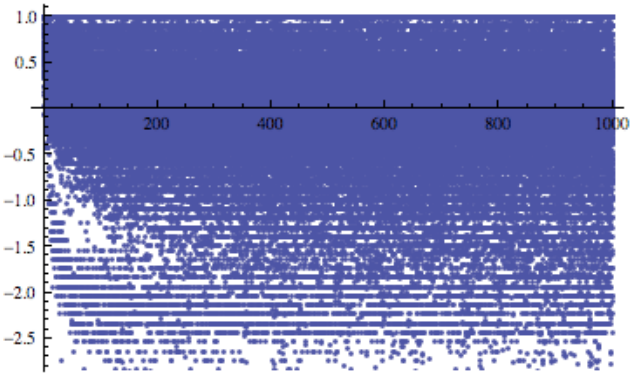
βss Small World

βss Scale Free

30







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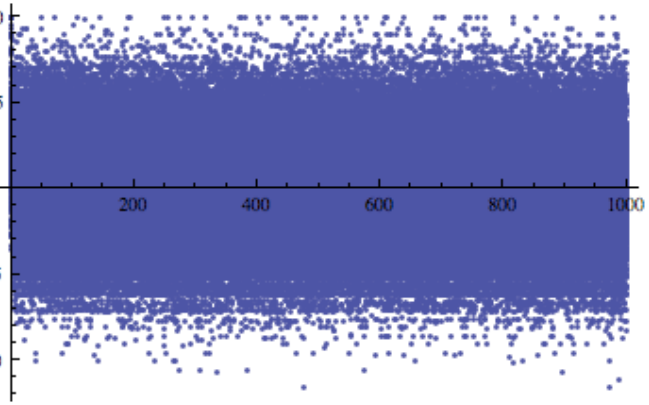

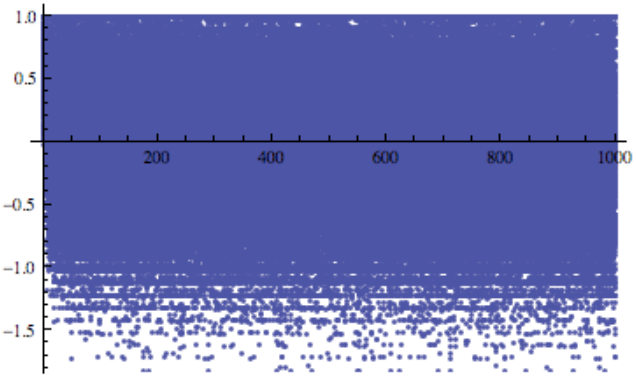

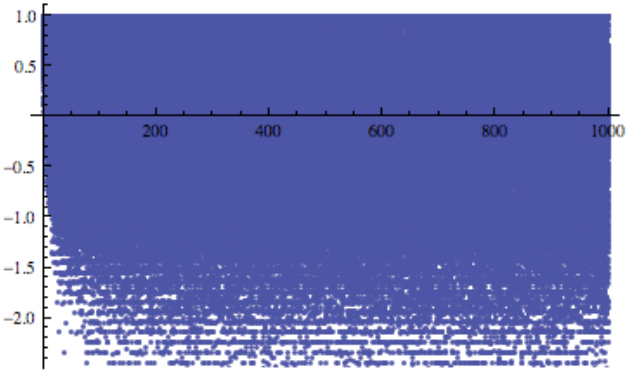

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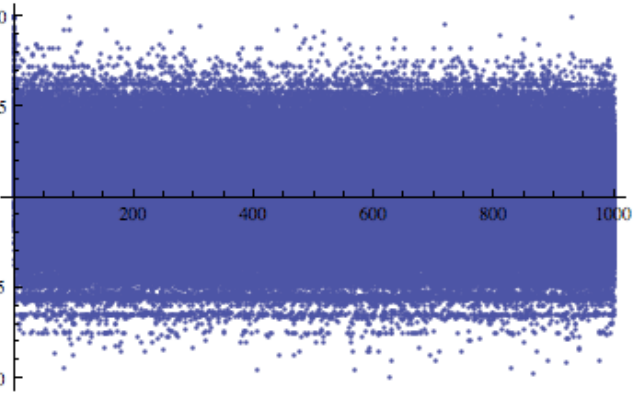

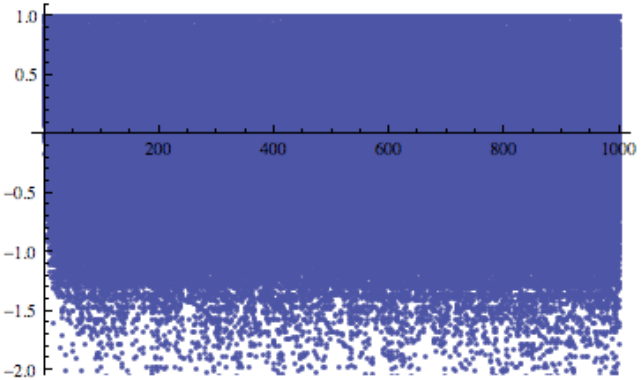

Finding Facts

- A multidisciplinary approach based on concepts from statistical physics, complex networks sciences is developed for the theoretical (scientific) description of collaborative learning processes.
- Using the emergence model, we find out that the network structure that is formed among learners in the classroom have much effect on the achievements reached in collaborative processes.

What remains to be seen

- more multidisciplinary approach to develop the theoretical (scientific) description of collaborative learning processes