

# LA PROGETTAZIONE DI MODULI DI INSEGNAMENTO SULLA SCIENZA DEI SISTEMI COMPLESSI PER SVILUPPARE COMPETENZE DI FUTURO: IL PROGETTO EUROPEO / *SEE*

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# The / SEE Project - Inclusive STEM Education to Enhance the capacity to aspire and imagine future careers



It's your time to imagine the futures



# The partners



# The / *SEE* project

- Goal:** To design innovative approaches and teaching modules to foster students' capacities to imagine the future and aspire to STEM careers
- Main research issue:** How can the contents of science (physics) be reconstructed so as to make disciplinary learning a place to develop skills to deal with the future (*future-scaffolding skills*)?
- Intellectual Outputs:** In order to realize future-scaffolding skills in STEM education, the / *SEE* partnership will develop innovative **teaching-learning modules** and **guidelines for teachers, research reports** and **policy recommendations**



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# What physics for future thinking?

Future is

- **intrinsic to physics** that has been developed also to manage rationally and emotionally the fear of the unknown
- strictly **related to the causal models** historically developed (from the linear and deterministic model of Newtonian physics to the non-linear models of the science of complex systems)



# Why science of complex systems?

**Science of complex systems** as a source of concepts (*feedback, scenario, projection instead of deterministic prediction, sensitivity to initial conditions, self-organization, space of possibilities*)  
precious to:

- appropriate causal models and a language suited to talk and think about the future (*develop future-scaffolding skills*)
- develop competencies (e.g. critical thinking) to read texts on complex socio-scientific issues (i.e. climate change) and to take an active and responsible part in public debates (*develop transversal citizenship skills*)



# The goals of the module

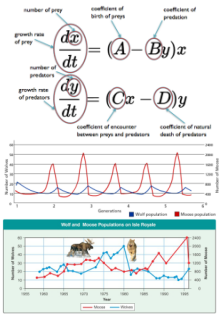
- Build **knowledge** about the contents, the procedures and the epistemology of science of complex systems (set A)
- Develop **scientific skills** to critically analyse cause-effect relationships within scientific texts on climate change (set B)
- Develop **future-scaffolding skills** by applying the scientific concepts to build probable, possible and desirable future scenarios (set C)



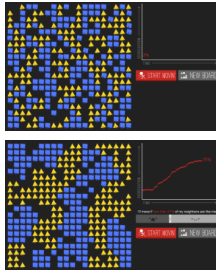


# The set A - Building *knowledge* about the science of complex systems

## Lotka-Volterra model



## Schelling's segregation model simulation



## Feedback Ted-Ed lesson



Which of the following is an example of a positive feedback loop?

- ☐ A As glaciers melt, there is less white surface to reflect heat, which causes more melting
- ☐ B As plants grow, their litter creates more soil humus, which in turn makes it hospitable for more plants
- ☐ C "Violence breeds more violence" - i.e. a violent act by one group causes their enemy to retaliate with more violence
- ☐ D All of the above

## "Game of life" simulation

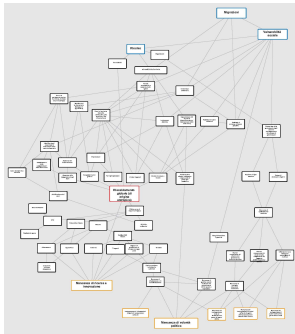


Activity	Disciplinary content	Application context	Form of presentation
Lotka-Volterra predator-prey model	non-linearity	ecological science	mathematical description and simulation
Feedback Ted-Ed lesson	feedback and circular causality	ecology, climatology, economics, computer science, molecular biology	video-lesson and interactive test
Schelling's segregation model	self-organization and emergent properties	sociological modelling	simulation
The Game of Life	self-organization and emergent properties	biological model	simulation

# The set B - Developing *scientific skills* to critically analyse cause-effect relationship within scientific texts on climate change

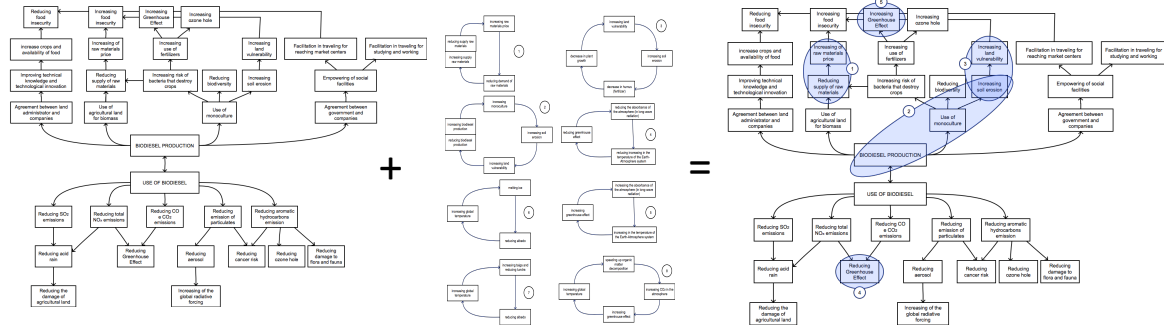
## Synthesis of the fifth IPCC report: the global warming issue

Global warming, in climatology, indicates an increase in the average temperature of Earth's surface and recorded in different phases of the climatic history of the Earth. [...]



## Use and Production of Bio Fuels: the "Biodiesel story"

Transport is one of the crucial themes as far as mitigation of climate changes are concerned, as it plays a central role in the domain of greenhouse gases emissions. [...]



Cause-effect linear map derived from the text

Feedback loops

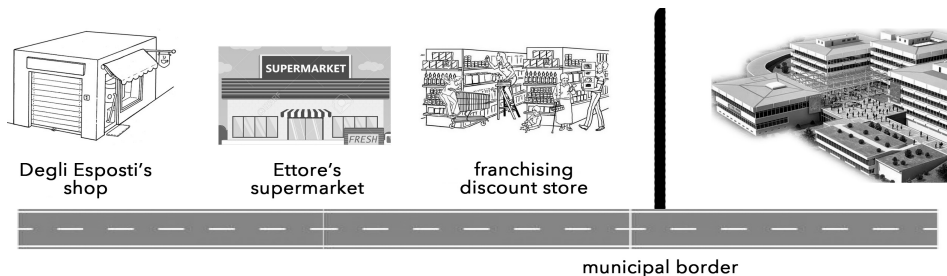
Cause-effect map enriched with feedback loops



# The set C – Developing *future-scaffolding skills* by applying the scientific concepts to build probable, possible and desirable future scenarios

## Probable, possible and desirable futures for the Town Irene

Irene is a small country town of about 8.000 inhabitants run-through by a large communication road. It counts three commercial areas, operating in the food sector. [...]



Activity 1: Analysis of the situation and identifications of scenarios

Activity 2: Identification of positive and negative feedbacks arising from given scenarios

Activity 3: Projection in a Desirable Future and present actions to realize it

Activity 4: Decision



# The pilot study

- PLS course on climate change (DIFA, UNIBO)
- Module of 9 hours
- 14 volunteer students (17-18 years old)



# Research methods

- Various research questions have guided the analysis of the data
- The data analysis has been carried out with an iterative qualitative strategy
- Here we report the main results with respect to only 2 research question



## RQ.1 - *Have the students developed scientific knowledge about the science of complex systems?*

**Yes**, most students reached the level of knowledge that we expected: they focused their attention on crucial aspects of the concepts of complex systems (i.e. **system**, **feedback**) and on the meaning of **prediction**

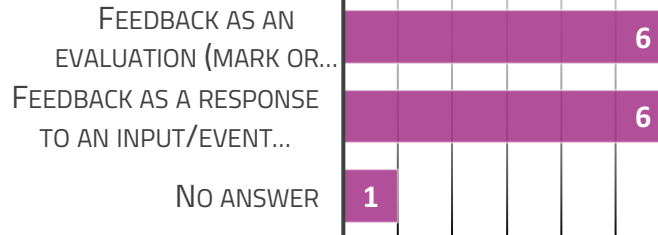


## Before the set A activities (pre-questionnaire 13 students)

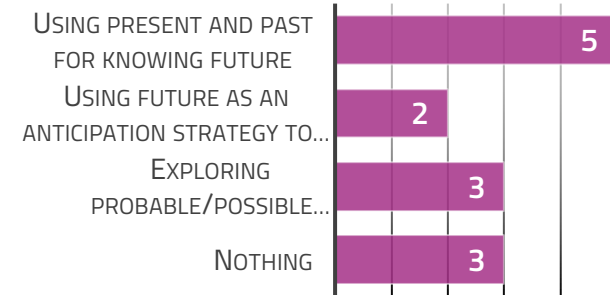
### SYSTEM

Something that can be isolated, close or open in relation with the environment

### FEEDBACK

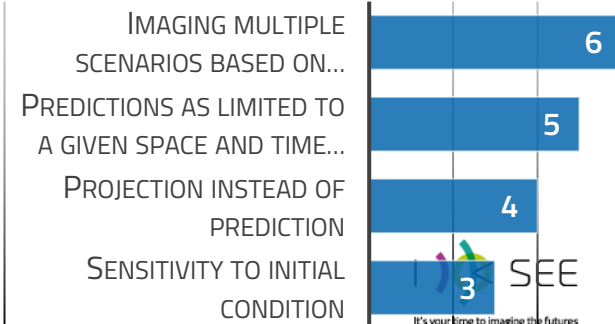
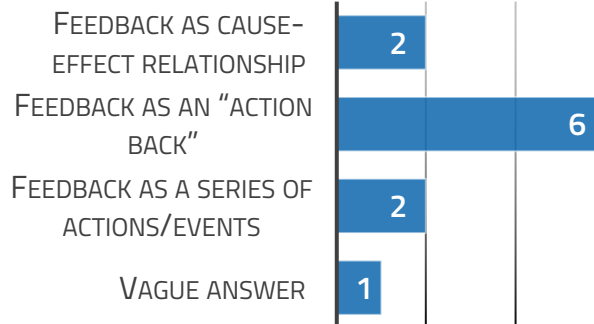


### PREDICTION



## After the set A activities (post-questionnaire 11 students)

Focus on the inner components of a system and on their mutual, internal, interactions



## RQ.2 - *Have the students developed future-scaffolding skills?*

**Yes**, the activities designed supported the development of these skills. For example, students

- learnt that the scientific concept of scenario requires a **language of 'possibilities'**
- became able to **imagine** creatively possible **future careers** to aspire
- **changed their perceptions of the present and the future**, learning that approaching climate change implies a change in ways we live in everyday life and we, collectively, make decisions





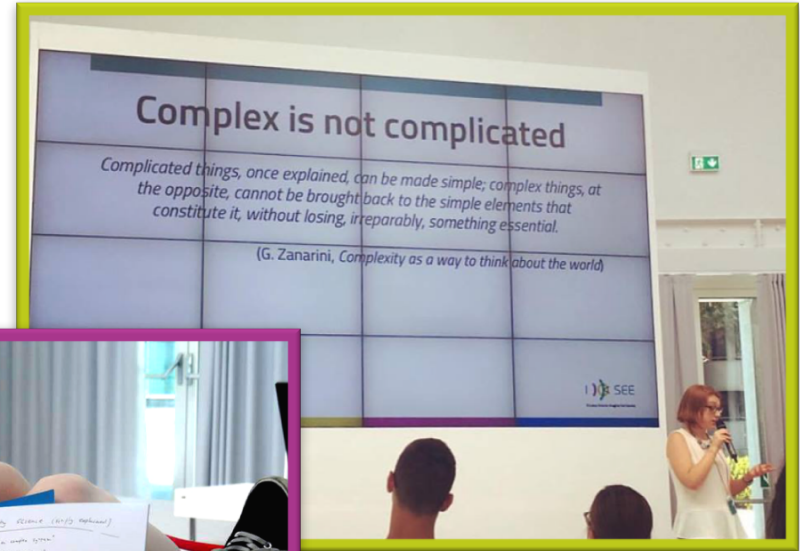
*"Oggi, ho capito quanto il mio approccio sia cambiato durante questo corso. Due mesi fa, avrei preso una decisione 'sì o no' in due secondi... Oggi abbiamo discusso due ore e ancora non sono sicura che sia la decisione giusta! Ho scoperto che ci sono così tante cose da tenere in considerazione..."*

(Stefania)



# The *I SEE* Summer School

The second  
implementation of  
the module was  
carried out during  
the first *I SEE*  
summer school in  
Bologna,  
5-9 June 2017



# Conclusions

Beyond some criticalities (students encountered difficulties in building causal maps, since they displayed a tendency to organize the information in **lists** and/or according to **pros-cons a-priori judgments**) the pilot study showed that the contents of physics can be reconstructed so as to make *disciplinary* learning a place to develop skills to deal with the future.



# Conclusions

The impact of the module on the perception of the future is particularly crucial in a society of acceleration (Rosa), where the future is often perceived not more as a promise but as a threat (Benasayag & Schmit).

