# Agent-based perspectives on epidemiological models: analysis of interviews with upper high-school students

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**Abstract.** One of the most popular models for the spread of diseases is constituted by a system of differential equations describing the evolution of susceptible, infectious, and recovered populations over time. However, agent-based epidemiological models can also be formulated based on interaction models from physics of complex systems. In this contribution, we discuss how upper high-school students, interviewed at the end of a teaching-learning module on computational simulations, develop their agent-based models for the spread of the virus, and how they construct analogies with agent-based models of complex systems previously encountered.

## Introduction

Computational modelling and simulations are nowadays a prominent part of the scientific research and practice, and they have applications in most disciplines, from physics to social sciences. However, rather than being a prerogative of scientists, with the climate change emergency and more recently with the COVID-19 pandemic, citizens have been called to enter social debates and decision-making processes also based on these tools. For these reasons, the educational research community is investigating new ways not only to embed simulations in disciplinary teaching but also to foster learners' awareness on these tools and their role as "third pillar" of scientific inquiry [1]. In this contribution we present the analysis of interviews conducted with upper high-school students at the end of a teaching-learning module on simulations of complex systems. The goal is to characterize how students constructed analogies between known agent-based models and a new issue proposed to them: the spread of a virus in a population.

## Research framework

Most simulations of complex systems can be categorized as equation-based or agent-based. In the former case, the system's evolution is described with differential equations; once they are solved, they give the future state of the system starting from the present. On the opposite, in agent-based simulations, the dynamics of the system is generated making the individual agents evolve according to behavioural rules. Since the 80s, researchers in science education have highlighted the potential of agent-based simulations to foster understanding of systems and to enter the mechanistic dimension of local interactions [2]. Especially when complex systems are addressed, the recognition of mechanistic elements of agent-agent interaction is fundamental to explain macroscopic emergent phenomena [3]. Specifically, previous research has shown that, when students try to model real-life issues constructing analogies with agent-based models of reference, they alternate reasonings that are typical either of the macroscopic or the microscopic level of the simulation [4, 5]. In particular, *macroscopic* levels of analogy's development are recognized when students reason in terms of aggregate, collective features of the system such as: i) its context of application, ii) the future evolution obtained, and iii) the emergent interaction among groups of agents. On the opposite, *microscopic* levels of analogy are detected when students refer to: i) the types of agents of the system, ii) the meaning of parameters and other elements of the simulation, or iii) the models of interaction among individual agents embedded in the simulation.

## Context and sample

In January-February 2021 a teaching-learning module on computational simulations was implemented for the first time online with 35 upper high-school students within an optional program of university orientation. In the module the students were progressively guided to analyse three NetLogo agent-based simulations of complex systems that are inspired by interaction models of statistical physics [6]. They are simulations of the Lotka-Volterra model for predation mechanism, of the voter model for opinion dynamics, and an evolutionary biology model for cooperative behaviour. At the end of the module, 8 semi-structured interviews were conducted and the volunteers were asked to develop verbally an agent-based model for the spread of a virus in a population and to outline possible analogies with the models previously encountered.

## Research questions and methods

This study aims at answering the following research questions: *How do upper high-school students develop their agent-based model to describe the spread of a virus in a population? In particular, how do they use known agent-based models to construct their new model by analogy?* To answer them, we analysed the anonymised transcripts of the 8 video-recorded interviews. The analytical process used qualitative methods inspired by grounded theory with explicit back and forth dynamics, from bottom-up data exploration to their theory-oriented interpretation [7]. More specifically, the transcripts were coded using the macro-micro categories of analogies' development illustrated in the framework, keeping always open the possibility of further enrichment of the theoretical basis. Then, we compared the different interviews to recognize, in the succession of codes, possible recurrent patterns.

## Results and conclusions

The comparison of the 8 interviews shows that students tend to exhibit the same pattern of opening and closing their modelling activity. They all start by focusing on the definition of agents and on the interactions among them, and end with a characterization of the analogy with the three given models that is positioned on the macroscopic level. However, the ways in which the analogical dimension is switched on vary across the students. Some spontaneously refer to the three simulations to ground on them their description of the interaction dynamics (microscopic level of analogies' construction) while others consider the given models only when explicitly requested and limit themselves to recognize similarities of contexts of application and overall evolution of the systems (macroscopic level of analogies' construction). Through the presentation of two contrastive cases, in the presentation we will highlight how the most effective modelling strategies connect macroscopic and microscopic levels by identifying and discussing the mechanisms of interaction underlying the evolution of the system.

## References


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