LESSON 1 · 1 OCTOBER 2026

Applied Systems Sciences 1

Course introduction: thinking in systems

Getting to know each other and the course

David Maier
Department of Environmental Systems Sciences
University of Graz

Before we start

Are you fine with calling each other by first name, including me?

1. Yes, first names are fine.
2. I would prefer surnames.
3. No preference.

About me

David Maier

University Assistant and PhD student, Environmental Systems Sciences

Software developer

Until 2024 a senior developer. I led the team behind a web platform that connects people with disabilities with personal assistants.

Researcher

How technological and biological solutions can be connected, using language models and knowledge graphs.

Studied here

BSc and MSc in Environmental Systems Sciences at this university.

What would you investigate?

If you were to pursue a career in research, what would you like to study or investigate?

1. **Think**
   A topic or a question is enough.
2. **Post it**
   First name, row, seat, interest.
3. **Introduce yourself**
   30 seconds each: name, studies, what you want to investigate.

Post your first name, your row and seat, and what you would like to investigate.

Who sits where, and what they investigate

The room plan fills in during the session.

Find your research team

15 minutes

Find people with whom you could develop an interesting research question.

You have **15 minutes** for the team, the question and sending it.

3 to 5 people

Per team. These are temporary teams for today.

Connect interests

They don't have to match. Your question should connect them.

Stay flexible

You can change teams while ideas develop.

Your output: one research question that connects each member's interest.

Send your team's research question

One member per team sends it.

Our research question

How did your team become this team?

1 First, individually

Note one decision you made.

2 Then, together

Reconstruct two or three events.

Questions to guide you

- Who approached whom first?
- What did you know about the people or teams you considered?
- What changed your options or your decision?

Record

- **What happened**
- **The reason reported**
- **What remains uncertain**

What influenced your choice?

Looking back, what most influenced how you joined your team?

A sentence is enough. There is no correct answer.

Main influence

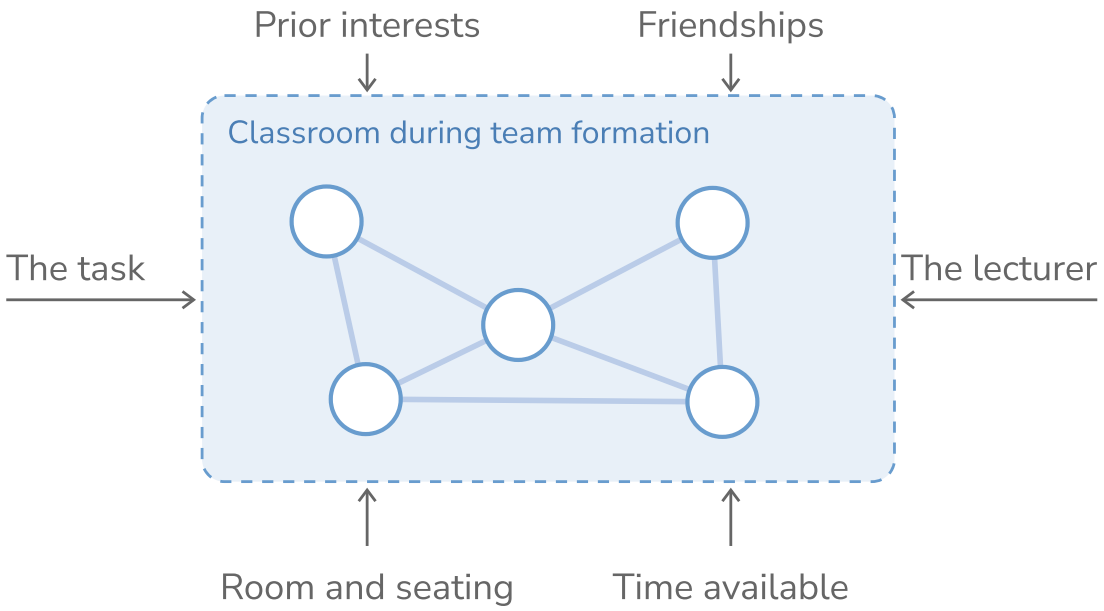
What happened? What might explain it?

Observed event	→	Possible explanation	→	What would help us check?
Three neighbours formed a team.		Being nearby made conversation easy.		Did they share interests or already know each other?

An example. We replace it with events from our teams.

Could we turn one explanation into a **rule** for how a student chooses?

A system is more than a list of people



Elements

Students with different interests and information.

Relationships

Acquaintances, conversations, invitations, memberships.

Boundary and context

Our task, the room, the lecturer, and the time available.

Mobus & Kalton (2015), Ch. 1 · Preiser et al. (2022), Ch. 2, pp. 33 to 38

What was given, and what emerged?

Given by the task

Teams of three to five.

Arose from your choices

Who joined which team.

Which interests came together.

Self-organisation: how memberships form.

Emergence: which patterns arise.

Railsback & Grimm (2019), Ch. 8.1 · Preiser et al. (2022), Ch. 2

Your choices change my options

1

Someone joins a team.

→

2

Fewer places remain.

→

3

Another student considers a different team.

Adaptation: adjusting a decision as the situation changes.

Your underlying interest can stay the same.

Did someone else’s decision change yours?

Railsback & Grimm (2019), Ch. 3, Table 3.1 · Preiser et al. (2022), Ch. 2

Would we get the same teams?

If we repeated the team formation 5 minutes later, which statement is most defensible?

1. Exactly the same teams must form.
2. The teams could stay the same or turn out differently.
3. Every team must change.
4. I am not sure yet.

How could we model these choices?

Represent students as **agents**, with states, information, and rules.

A	B	C	D	E	F
Ecology	Computing	Ecology	Computing	Ecology	Computing

Six fictional students · Nobody has a team yet · Interests stay fixed · At most three per team

“Approach someone with a related interest.”

What can A know?

A could choose C or E. How should A decide?

Does the other person have to agree?

Our model question: how do choices produce team memberships?

Railsback & Grimm (2019), Ch. 1.2 and 1.4 · Schlüter et al. (2022), Ch. 28

My goals for this semester

Model

Carry out the whole modelling cycle yourself, from conception through implementation to interpretation.

Analyse

Analyse, simulate, and critically reflect on complex systems with agent-based models.

Code

Deepen your Python basics and learn to work with coding agents.

Collaborate

Learn a bit how real software teams collaborate, with git and GitHub.

Enjoy

Find out that coding can be fun with the right tools.

And one for me

I want to test my interactive slide deck on you.

From a question to a working model

In this course, you will analyse systems, build models in Python, and examine what you can learn from them.

1 Observe a process. → **2** Propose an explanation. → **3** Describe and implement a model. → **4** Compare results with evidence.

Revise the question, assumptions, or model as you learn.

Railsback & Grimm (2019), Ch. 1.3 · Schlüter et al. (2022), Ch. 28

What we will do

Seventeen appointments, three parts

1

Introduction and basics

Sessions 1 to 4

Systems, feedback, emergence, the modelling cycle, agent-based models. Setup of Python, VS Code, git and GitHub.

2

First models

Sessions 5 to 8

From ODD to code with a traffic model. Analysing runs. LLMs from Python.

3

Group projects

Sessions 9 to 17

Your own agent-based model in a small group, with presentations of your preliminary work and of the results.

From session 5 on, we spend most of the time coding. Your dev setup should be done by then; the cheatsheet helps with Python.

Which AI tools do you have?

Do you have a Claude Pro or ChatGPT Plus subscription?

1. Yes, Claude Pro.
2. Yes, ChatGPT Plus.
3. Yes, both.
4. No, neither.

What do you take away from today?

Name **one thing** you take away from this lesson.

Something you see differently now.	Something that surprised you.	A question you still have.

Your takeaway

Before the next session: register a GitHub account

1

Sign up

A free account at **github.com**. Already have one? Use it.

2

Pick a username

One you are fine with the class seeing.

3

Send it to me

Post your username on Moodle.

On the course website, GitHub **identifies you** in the participation exercises.

In the group projects, GitHub is **the main tool for collaboration**.

Also apply for GitHub Education at **education.github.com/students**: as a student you get free Copilot usage. Approval is not instant, so apply early.

Sources for this lesson

Railsback, S. F. & Grimm, V. (2019). *Agent-Based and Individual-Based Modeling: A Practical Introduction.* 2nd ed.
Ch. 1: models and ABM; Ch. 3: design concepts; Ch. 8.1: emergence.

Mobus, G. E. & Kalton, M. C. (2015). *Principles of Systems Science.*
Ch. 1: systems, relationships, and boundaries.

Biggs et al. (eds., 2022). *The Routledge Handbook of Research Methods for Social-Ecological Systems.*
Preiser et al., Ch. 2, pp. 33 to 40: relationships, adaptation, and context.
Schlüter, Lindkvist, Wijermans & Polhill, Ch. 28, pp. 383 to 389: agent-based modelling.

The classroom activity and toy model are teaching examples. Their outcomes are not findings from these sources.