Key words:
Scratch, systems thinking, complexity, nonlinearity, turtle geometry, dynamic systems

What is a system?

A system is an organized whole to achieve a common goal. Parts of the system works together to achieve this common goal.

In her book "Thinking in Systems" Donella Meadows argue that "a system isn't just any old collection of things. A *system* is an interconnected set of elements that is coherently organized in a way that achieves something. If you look at that definition closely for a minute, you can see that a system must consist of three kinds of things: *elements*, *interconnections*, and a *function* or *purpose*."

In the same book Meadows gives us the following as a summary of systems principles:

- A system is more than the sum of its parts.
- Many of the interconnections in systems operate through the flow of information.
- The least obvious part of the system, its function or purpose, is often the most crucial determinant of the system's behavior.
- System structure is the source of system behavior. System behavior reveals itself as a series of events over time.

Systems Thinking

Systems thinking is thinking about systems. The core of systems thinking is to think about the parts of the system, interrelations between these parts and the purpose the system aims to achieve. Systems thinking is to think about how systems are organized and how they work.
We all live, work and learn in systems. We are also a system. Although we are always surrounded by systems we don't know much about the principles of systems. It would be

helpful to learn about the characteristics of systems since we simply exist in systems.

Systems thinking is an essential part of 21st century skills. However just to think about systems is not enough. We have to recognize the fact that most of the time we are dealing with dynamic systems. Dynamic systems change with time and show complex behavior. In these systems cause and effect are not in the same time and space. Dynamic systems are nonlinear which means that a small change can cause a huge effect on the behavior of the system. Here is how Resnick and Zuckerman looks at systems thinking and why should we learn about systems:

> System dynamics (SD) and system thinking (ST) are methods for studying the world around us. They deal with understanding how complex systems change over time, and how structure influences behavior (Forrester 1968; Senge 1990).
>
> Learning to understand dynamic systems is an essential step in understanding the world around us. However, learning it at university, high school or even middle school level might be too late. By this age children already develop their own models of how the world works.

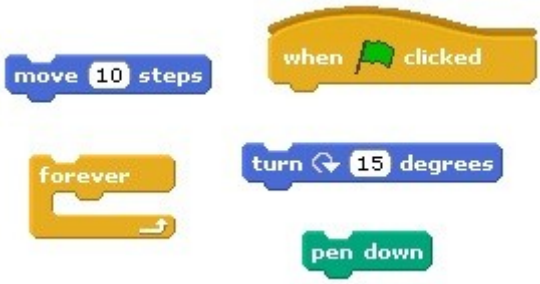
An interesting explanation comes from Murray Gell-Mann while he is explaining their area of research at Santa Fe Institute:

> ...we devote ourselves to studying, from many different points of view, the transdisciplinary subject that includes the meanings of simplicity and complexity, the ways in which complexity arises from fundamental simplicity, and the behavior of complex adaptive systems, along with the features that distinguish them from non-adaptive systems. My name for that subject is plectics, derived from the Greek word plektós for "twisted" or "braided," cognate with the principal root of Latin complexus, originally "braided together," from which the English word complexity is derived. The word plektós is also related, more distantly, to the principal root of Latin simplex, originally "once folded," which gave rise to the English word simplicity. The name plectics thus reflects the fact that we are dealing with both simplicity and complexity.

Scratch is a beautiful example of the idea of "braided togetherness."

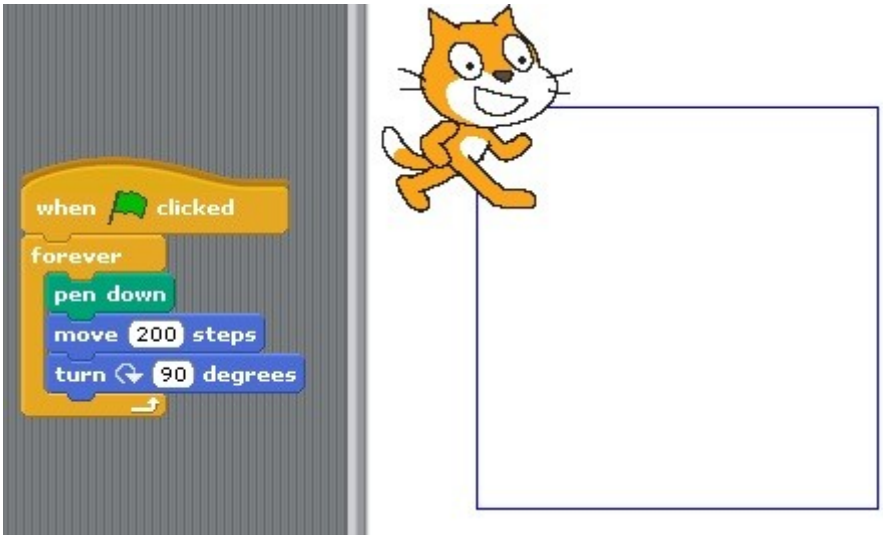
Scratch and Systems Thinking Skills

We can use Scratch and Turtle Geometry to understand what systems thinking is:

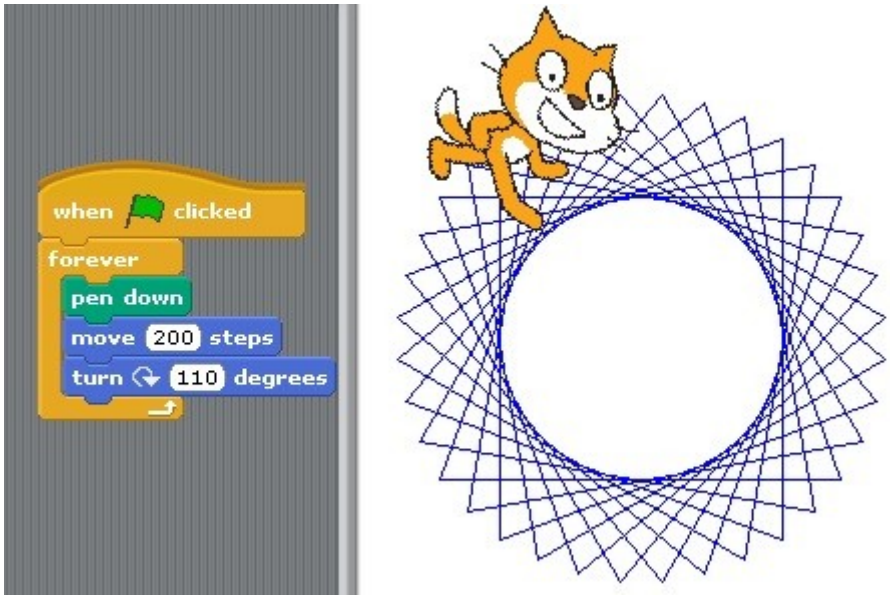


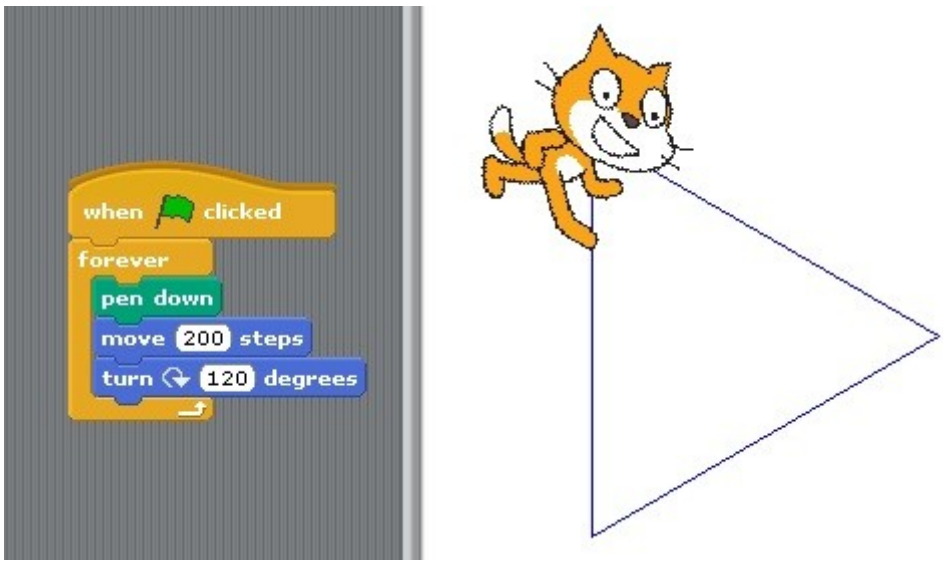
What are the parts of the system?

Scratch helps us to see how the parts of the system come together to behave in a meaningful matter:

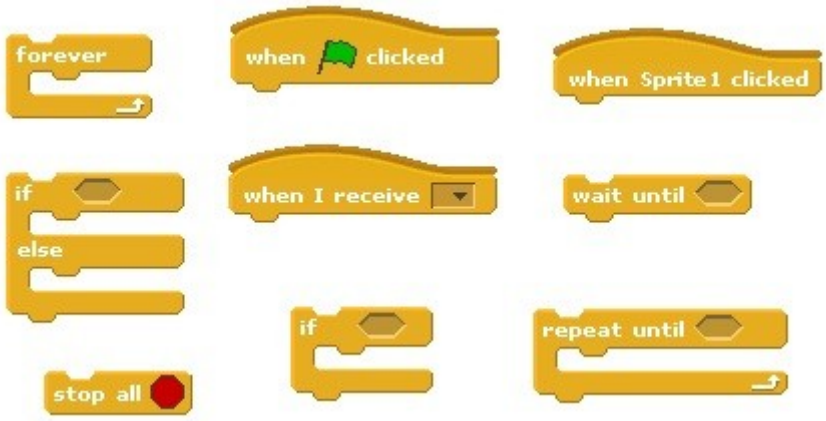


With Scratch we can see how small changes produce an unexpected and nonlinear behaviour:





What is the purpose of the system and how can we control it?



Donella Meadow's Guidelines for Living in a World of Systems (from the book Thinking in Systems):

1. Get the beat of the system.
2. Expose your mental models to the light of day.
3. Honor, respect, and distribute information.
4. Use language with care and enrich it with systems concepts.
5. Pay attention to what is important, not just what is quantifiable.
6. Make feedback policies for feedback systems.
7. Go for the good of the whole.
8. Listen to the wisdom of the system.
9. Locate responsibility within the system.

10. Stay humble—stay a learner.
11. Celebrate complexity.
12. Expand time horizons.
13. Defy the disciplines.
14. Expand the boundary of caring.
15. Don’t erode the goal of goodness.