

# MODELING AT SCHOOL FRAMEWORK



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### MODELING AT SCHOOL FRAMEWORK

**Introduction:** The Modeling at School (MAS) Project • The Modeling at School (MAS) Framework

**Modeling as a Concept, Process and Tool:** Computational Thinking and Modeling in European Education • Modeling in all school subjects • Modeling as an effective and creative learning tool

**The Diagrams:** Overview • Modeling with Diagrams • Activity Diagram • Use Case Diagram • Class & Object Diagram • Entity-Relationship Diagram

**Modeling in the Key Competence Development:** Key competences, computational thinking, modeling and curricular subjects

# More information about the project: an and mants to see and enteriorice in activity diagram the day before. petiled the different shapes. The Modeling at School (MAS) PROJECT

### THE MODELING AT SCHOOL (MAS) PROJECT

The "Modeling at School" (MAS) European Union's Erasmus+ Project (2018-2021) is focusing on modeling in a non-informatic setting. The main aim of its project partners from Austria, Finland and Spain is to support teachers and students in implementing modeling in different school subjects and in crosscurricular settings. In each partner country, at least five schools take part in the project.

Modeling is a structured process for problem-solving and it can make a **positive impact** in several domains from designing systems to organizing complex information. The model describes an image of the reality on an abstract level. **Applying the process of modeling in everyday learning can be a powerful tool** to understand, summarize, present or memorize difficult contents, describe and develop processes, as well as oversee and perform various procedures. **Modeling as an activity is contributing to the development of key competences for lifelong learning, and efficiently supporting 21st century skills**.

Based on a Curricula Analysis conducted in Austria, Finland and Spain, strategies were established for integrating modeling into teaching and learning activities. These strategies were turned into a Ready-To-Use-Guideline for implementing modeling in formal and nonformal learning settings. With the Educational Pyramid **Scheme**, a possibility to efficiently implement innovations in the school system is being tested within the project. The participants are trained in using modeling as a teaching and learning strategy. They will share their knowledge in their school communities. The purpose of the MAS Framework is to provide an introduction for educators, educational leaders, and policymakers on the potentials of integrating modeling in the curricula. Furthermore, in cooperation with the partner schools, a Collection of Materials for various school subjects is established. These materials will be freely accessible. Finally, the MAS project will provide a **Digital Modeling Tool**, which will enhance the implementation of modeling in schools.

#### INTRODUCTION

#### See:

Council of the European Union (2018). Council Recommendation on Key Competences for Lifelong Learning.

#### Source:

http://data.consilium.europa. eu/doc/document/ST-9009-2018-INIT/EN/pdf

Modeling at School (MAS)

# FRAME WORK

#### THE MODELING AT SCHOOL (MAS) FRAMEWORK

The Modeling at School (MAS) Framework aims to support the integration of **computational thinking** and **digital literacy** as a transversal theme in **primary and secondary education**.

MAS Framework's goal encourage is to policymakers/authorities, educational organizations, and educators to find ways to use **modeling as a teaching** and learning tool in all school subjects and crosscurricular projects. It demonstrates how subjectspecific content can be linked together by modeling and how modeling can enhance competence development, according to the European Council's recommendation on European Key Competences for Lifelong Learning (2018).

Modeling activities can support **problem-solving skills**, **structured and algorithmic thinking**, **abstraction**, **generalization**, **text comprehension**, **creativity**, and many more skills and cognitive domains of learning.

The **MAS Framework** provides an introduction to modeling as a concept, process, and tool. It provides examples of models for different purposes by presenting sample diagrams covering everyday life topics that can be easily transferred to various curricular settings. It also demonstrates how modeling is connected with the development of key competences for lifelong learning and how it can be fitted into all subjects and school levels in national curricula.





### THE MAS FRAMEWORK ENTAILS:

- general information about modeling as a concept, process, and tool,
- examples of models for different purposes, and how to link modeling to subject-specific contents, topics, competencies, and activities, and
- examples how modeling is connected with the development of key competences and how it can be fitted into all subjects and school levels in national curricula.



#### See:

Computational thinking definition and relationships between different subjects.

#### Source:

https://k12cs.org/ computational-thinking/

#### See:

Unified Modeling Language (UML) an overview, diagrams associated and examples.

#### Source:

https://www.visualparadigm.com/guide/umlunified-modelinglanguage/what-is-uml/

Modeling at School (MAS) MODELING AS A TOOL

#### MODELING AS A CONCEPT, <u>PROCES</u>S AND TOOL

**Modeling** is the process of building models, which is an essential element within the human ability to reason about **real-life problems.** Modeling can be viewed as the mother tongue of problem-solving. Modeling includes various thinking processes such as **abstraction**, **reduction**, **structuring**, **and generalization**. These processes are also part of **computational thinking**. **A model is a simplified representation of a section of reality**, e.g. of objects, situations or processes. This representation seeks to capture essential information and elements in the form of **diagrams**. A diagram can be defined as **a visual representation to illustrate the information**. For instance, we can model **the daily routine of taking the bus** with an **activity diagram**.

Computational thinking is a critical set of problemsolving skills that are necessary for the new generations of digital learners. These skills include, e.g. abstraction, generalization, decomposition, parallelization, data representation, synchronization, and usage of modularity. As a part of computational thinking, modeling techniques and diagrams have lots of potential and possibilities because they can be used to visualize not only structures and relationships but also processes, instructions, situations, and events alike.

Modeling has been extensively used in Computer Science, as a key component in the software development process. Traditionally, Unified Modeling Language (UML) has been the main graphical modeling language used in Computer Science.

Implementing modeling as a concept, process and tool in learning of various school subjects is an innovative trend in education. Together with teachers and school leaders, the authors would like to provide a comprehensive support in making modeling a part of everyday learning situations.

# Computational Thinking and Modeling in European Education

# OVERVIEW

The development of **logical thinking**, problem-solving, and learning-to-learn skills begin in European education at an early age. Abstraction, analyzing, and modeling, along with other computational thinking skills are promoted across different subjects at primary and secondary education.

The relevance of **computational thinking** in education is growing: computational thinking is a critical component of the leading educational policies in the European Union. **Modeling**, as the fundamental concept of computational thinking, provides connections to all competence areas in the **European key competence framework**.

Several examples prove that the development of computational thinking in today's schools is no longer limited to activities such as coding. Current educational trends offer **computational science activities** even "unplugged", without using a computer. **Modeling** can be a powerful tool in organizing complex information for **systematic learning**, **understanding**, and **memorizing processes**. There is an opportunity to implement diagrams and algorithmic approaches in any school subjects as well as in multidisciplinary learning and cross-curricular projects.

The **MAS project** has thoroughly analyzed the **Austrian**, the **Finnish**, and the **Spanish** national core curricula. The **descriptive curricula analysis** ranked the **most common computational thinking-related keywords** in the Austrian, Finnish, and Spanish primary and secondary curricula.

#### They were:

- characteristics,
- properties,
- knowledge,
- structure,
- logi<mark>c</mark>,
- relationship,
- procedure,
- process,
- model/modeling,
- represent/representation,
- decomposing,
- analysing,
- visualizing,
- presenting, and
- text comprehension.

The term "process" occurred in all countries. Apart from some differences, concepts related to **computational thinking and modeling** are firmly established in all educational systems. This suggests that modeling is the ideal instrument to put concepts like **analytic**, **structural**, **procedural**, **and relational thinking** into practice.

#### Useful links:

- Descriptive Curricula Analysis in the MAS Project: https://computationalthinking.guru/output-io1/
- EU Science Hub's Computational Study: https://ec.europa.eu/jrc/en/computational-thinking
- Computational Thinking and Acting Erasmus+ Project (COTA): https://www.jyu.fi/it/en/research/researchareas/cognitive-science-and-educationaltechnology/ile/projects/cota
- Computer Science without a Computer Project: https://csunplugged.org/en/

### MODELING IN ALL SCHOOL SUBJECTS



Models serve as a base for solving complex problems in different school subjects and in cross-curricular projects. Here you can find an overview of various reasons for using modeling:

### Part of the Curriculum

+ Formalization + Abstract thinking + Problem-solving

# Effective teaching & learning strategy

+ Graphical organizer
+ Diagrams
+ Summarize content
+ Keep essential information Integrative computational thinking in practice

+ "Mother tongue" of Computer Science + Ideal for interdisciplinary learning

# Modeling as an effective and creative learning tool

Modeling can be used as innovative and effective teaching and learning strategy as it serves as an excellent graphic organizer. A graphic organizer helps to structure content to be learned. It is recommendable to introduce it to the learners at an early stage of the learning process. Diagrams support the visualization and graphic structuring of the content. Modeling and diagrams are particularly useful for:



56 "Modeling is the mother tongue of problem-solving."

# **Overview**

#### MODELING WITH DIAGRAMS

Fostering key competences and 21st-century skills in school is not easy, but necessary. Teachers face the challenge of teaching both the subject matter and supporting the development of various skills at the same time. Using diagrams as teaching and learning strategy is a very practical way to fulfill both of these expectations.

# The diagrams presented here are brain-friendly visualization tools, based on informatic modeling.

#### THE DIAGRAMS

Different diagrams serve best for different purposes. Here you can find an overview and, in the following pages, some examples of the best practices when using diagrams in teaching and learning.

Structures & Categories

# Rules & Procedures

+ class diagrams + object diagrams + graphs + activity diagrams + flow charts + graphs Situations & States

 + use case diagrams
 + entity relationship diagrams
 + state diagrams

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# Activity Diagram

Improve students' algorithmic thinking skills. Be it a cooking recipe, grammar rules or a chemical experiment. The activity diagram helps to visualize single steps of activities, procedures and rules.

Foreign Languages

0

Political Education



#### THE DIAGRAMS

# **Use Case Diagram**

#### SITUATIONS, STATES & RELATIONS: THE BIG PICTURE



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#### THE DIAGRAMS

# **Class & Object** Diagram

STRUCTURE, CATEGORIZE AND BRING **IMPORTANT TERMS ON PAPER** 

The class diagram is an ideal tool to structure vocabulary and visualize hierarchies.

Geography

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## Entity-Relationship Diagram VISUALIZE SITUATIONS, STATES & RELATIONS

Entity-relationship diagrams are perfect to begin with modeling. With just a few shapes, it is easy to acquire and helps to remove complex syntax by visualizing the most important elements of a text.



MODELING IN THE KEY COMPETENCE DEVELOPMENT

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MAS project puts a great emphasis on the potentials of modeling in the key competence development.

On the European level, the European Council Recommendation on Key Competences for Lifelong Learning (2018) proposes eight key competences. These competencies are integrated in MAS-project countries' education on different ways. The Finnish National Core Curriculum for Basic Education, for instance, focuses on the so-called transversal competences as part of every subject. Similarly, the Spanish curriculum is organized according to basic competences. Also, the teaching and learning in Austrian schools are already competenceoriented.

In this project, study of modeling-based а key competences was carried out as part of the curricula analysis. It was focusing on competences on the national level in Austria, Finland and Spain, as well as on the European level. In the following pages, there is an overview of the competence-related knowledge, skills, and attitudes that can be developed through modeling and computational thinking.

See: Council of the European Union (2018). Council Recommendation on Key Competences for Lifelong Learning.

http://data.consilium.europa.eu/ doc/document/ST-9009-2018-INIT/EN/pdf



MODELING IN THE KEY COMPETENCE DEVELOPMENT

#### KEY COMPETENCES, COMPUTATIONAL THINKING, MODELING AND CURRICULAR SUBJECTS

### European Key Competences for Lifelong Learning

Knowledge, skills, and attitudes to be developed through computational thinking and modeling

# Literacy competence

Searching, identifying, understanding, processing, collecting, expressing, creating, formulating, assessing and interpreting information in critical and creative way. Subject examples in primary and

secondary school

Mother tongue

Second language

Foreign language

# Multilingual competence

Supporting language learning and understanding of grammar. Understanding, expressing, interpreting concepts, thoughts, feelings, facts, and opinions.

Second language

Foreign language

Mathematical competence...

Developing and applying mathematical thinking for problem solving. Applying mathematical modes of thought, reasoning, argumentation, and presentations.

#### Mathematics

#### KEY COMPETENCES, COMPUTATIONAL THINKING, MODELING AND CURRICULAR SUBJECTS

### European Key Competences for Lifelong Learning

Knowledge, skills, and attitudes to be developed through computational thinking and modeling

.. and competence in science, technology and engineering Using logical and rational thought and scientific inquiry, understanding of science as a process. Understanding changes caused by human activity and responsibility as an individual citizen.

#### Subject examples in primary and secondary school

Environmental Studies Physics Chemistry Biology Geography

Digital competence

Using digital technologies in a confident and responsible way. Understanding the mechanisms and logic underlying digital technologies, safety and wellbeing.

# ICT as a subject

Robotics

Personal, social and learning to learn competence Managing and organising one's own learning and learning strategies. Dealing with complexity and having problem-solving attitude. Organising and persevering with one's learning, evaluating and sharing it, Health Education Home Economics Religion Ethics

#### KEY COMPETENCES, COMPUTATIONAL THINKING, MODELING AND CURRICULAR SUBJECTS

### European Key Competences for Lifelong Learning

Knowledge, skills, and attitudes to be developed through computational thinking and modeling

Citizenship competence Understanding historical, social, political, socioeconomic, demographic, climate, and cultural issues. Developing critical thinking, problem-solving, participation, and argument development.

Entrepreneurial competence

Developing strategic thinking. Planning and managing projects including both processes and resources.

Cultural awareness and expression competence Expressing and interpreting figurative and abstract ideas, experiences, emotions and meaning creatively and with empathy. Subject examples in primary and secondary school

History Social and Political Studies Law Geography Religion Ethics

> Economics Guidance counselling Tutoring

Visual arts Crafts History Social Studies Music Physical Education Religion Ethics



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HAVE A LOOK AT OUR ONLINE FUTORIALS



(YouTube channel: "Modeling at School Diagram Guru")

### OR CHECK OUR WEBSITE

www.computationalthinking.guru

### FOLLOW US







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