Computational Thinking for Everyone?

Modeling for Everyone!

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Why?

• Austrian Curricula
  • Secondary school curriculum
    • “Basic Digital Education” incl. computational thinking [1]
  • Primary school curriculum
    • Capacity of abstraction by using diagrams or symbols
    • Basic cognitive processes like comparing, sorting, classification, abstraction, generalization etc. [2].
  • CT and modeling involve these thinking processes!

• International Research
  • Informatics didactics - Approach „Models first“ in CS education
    • Modeling determines way of thinking in problem solving
    • Modeling = „mother tongue of problem solving“ [3]
  • Neurodidactics
    • Modeling effective learning strategy (concept maps [4])

• Personal Teaching Experiences
  • Computer science
  • Foreign languages
Text Comprehension & Production

![Diagram showing the process of making a hotel reservation and checking in and out a guest.]

- Receptionist
  - Hotel
    - make reservation
    - check in guest
      - check out guest
  - Guest
Overview

• What?
  • CT = Problem solving methodology
  • Modeling = Brain-supporting learning strategy

• How?
  • CT & Modeling in practice
  • Sample projects & Activities
  • Experiences & Results

• Conclusion & Outlook
What?

• Computational Thinking =
  • „Problem solving process“ [5]
  • „[..] the use of *computer science concepts to solve a problem in any domain“ [6]
  • “[..] the goal of computational thinking is to solve problems” [7]

• Modeling =
  • Building models, *abstract description of a real or planned system* [8],
  • reduced and simplified representation of real world, containing only *essential information* or elements
COMPUTATIONAL THINKING

PROBLEM SOLVING
CT = Problem-Solving Process

That includes (but is not limited to)
• **Formulating problems** in a way that enables us to use a computer and other tools to help solve them
• **Logically organizing** and **analyzing** data
• **Representing** data through **abstractions** such as **models** and simulations
• Automating solutions through **algorithmic thinking** (a series of ordered steps)
• **Identifying**, **analyzing**, and **implementing** possible **solutions** with the goal of achieving the most efficient and effective combination of steps and resources
• **Generalizing** and **transferring** this problem-solving process to a wide variety of problems [5]
4 Stages of CT

- **Decomposition**
  break down a problem into subproblems

- **Pattern recognition**
  notice similarities, differences, properties, or trends in data

- **Pattern generalization**
  extract unnecessary details and generalize those that are necessary in order to define a concept or idea in general terms

- **Algorithm design**
  build a repeatable, step-by-step process to solve a particular problem [9]
MODELING AT SCHOOL

1. FOSTERING COMPUTATIONAL THINKING
2. BRAIN-BASED LEARNING STRATEGY FOR DIFFERENT SUBJECTS
Computational Thinking

Problem: Arriving at school in time

- Decomposition: subproblems
  - Leave
  - Check time
  - Decide
  - Go (by foot or bus)
  - Arrive

- Pattern recognition
  - Always the same

- Pattern generalization
  - Essential + general elements

- Algorithm design
  - Step-by-step solution
Modeling supports

• Problem solving
  • Analyzing problems
  • Breaking down in smaller problems
  • Finding solutions for small problems
  • Combining parts to complete solution

• Text comprehension & production
  • Recognizing and extracting essential information
  • Summarizing texts
  • Understanding the “big picture” and relationships
  • Creative writing and storytelling

• Knowledge acquisition & representation
  • Structuring
  • Categorizing
  • Abstraction
  • Generalization
  • Visualization

• Etc.
Modeling = Learning Strategy

• Modeling **in general**
  • Concept maps and other **visualization** techniques
    -> Supports the learning process in the human brain [10]
  • Benefit of **priming effect** – implicit memory effect:
    an appropriate unconscious stimulus influences (positively) the memorizing
    of the following input
  • **Advanced organizers** (brain needs structure!)
    -> Especially effective for children with learning difficulties [4]

• Modeling with **diagrams** from **computer science**
  • Same benefits – more possibilities
    • Numerous diagram types
    • More different learning purposes and situations
  • Teaching **computational thinking & digital literacy**
    -> demanded in curriculum & as 21\textsuperscript{st} century skills
How?

CT & Modeling in Practice
Connecting CT to Everyday Life
Example: Activities of Primary School

• Organizing, searching, sorting pictures & objects
  ➔ Searching & Sorting

• Traffic signs & secret languages
  ➔ Encoding & Encryption

• Finding generic terms & similarities
  ➔ Abstraction & Generalization

• Describing the way & step-by-step instructions
  ➔ Algorithms & Modeling
### Programming: Declaration of variables

- **Farbe/Colour**: Colour
- **Nr.**: Number
- **Bezeichnung**: Description
- **Bezeichnung**: Description
- **Front part**: Front part
- **Back part**: Back part
- **Trimming, cut 4 times!!**: Trimming, cut 4 times!!
- **sleeve cuffs**: Sleeve cuffs
- **left front skirt panel**: Left front skirt panel
- **pleat's piece**: Pleat's piece
- **right front skirt panel**: Right front skirt panel
- **Inner lining of the skirt**: Inner lining of the skirt
- **Back skirt panel**: Back skirt panel
- **Belt, 95 cm long, 3 cm wide**: Belt, 95 cm long, 3 cm wide

### Encoding

- **Erforderlich: etwa 3,50 m Stoff, 90 cm breit; 0,80 m Stoff, 90 cm breit für Garnitur**

- You'll need about 3.50 m fabric (90 cm wide); 0.80 m fabric (90 cm wide) for trimming

### Modeling

- **http://neu4bauer.blogspot.co.at/2011/04/freebie-vintage-pattern-from-our-april.html**, adapted

Close darts, side and side seams. Sew the sleeves into doubled fabric of the cuffs. Double the collar and sew into the serged neckline. Turn over both the front skirt pieces at the buttonholes as well as the left skirt piece. Crimp all the pleats into place and place the right skirt piece on the pleat's piece allowing only a very narrow lap.

Close darts and side seams. Sew the skirt onto waistline. The left front part is only sewn till the button ridge of the left front panel. The loose part is fastened with a press-stud in the inner part of the dress. Double belt and close the belt with a press-stud too.

A pattern by neu4bauer.blogspot.com
Designing & Modeling a Shirt
1. **How and where** can we **introduce modeling** in primary and secondary education?

2. Which **modeling techniques** are **useful** and practicable for teachers and students **without** informatics background?

3. Which dimensions and aspects of the modeling process are or shall be **part of general education**?

4. Is it possible to **improve general learning competencies** like abstraction, problem solving, text comprehension etc. by a frequent and varied use of modeling in primary and secondary education?
# Modeling across the Subjects – Projects Overview

<table>
<thead>
<tr>
<th>Project</th>
<th>Students (School)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informatics Summer Lab (2014)</td>
<td>77 (6 - 17 years)</td>
</tr>
<tr>
<td>Informatics - A Child's Play?! (Sparkling Science, 2014-2018)</td>
<td>150 (primary, secondary)</td>
</tr>
<tr>
<td>Modeling in English language teaching (Diploma thesis, 2015)</td>
<td>141 (lower secondary)</td>
</tr>
<tr>
<td>Game design in English as foreign language (Case study, 2016)</td>
<td>19 (higher secondary)</td>
</tr>
<tr>
<td>Modeling at school (EU project application, pilot phase, 2018)</td>
<td>57 (secondary)</td>
</tr>
<tr>
<td><strong>Participants (total)</strong></td>
<td><strong>444</strong></td>
</tr>
</tbody>
</table>
Which Models in Which Context?
Activity Diagrams

- Instructions
- Activities
- Decisions
- Stories
- Rules

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>start</td>
</tr>
<tr>
<td>○</td>
<td>finish</td>
</tr>
<tr>
<td></td>
<td>activity</td>
</tr>
<tr>
<td>☐</td>
<td>question or decision</td>
</tr>
</tbody>
</table>
Modeling Processes: Flow Chart

- Leave home
- Check time
- Is it before 7 am?
  - Yes: walk
  - No: take the bus
- Arrive at school
- Useful for
  - Processes
  - Rules
  - Instructions
# Class & Object Diagrams

- **Vocabulary**
- **Characteristics**
- **Word classes**
- **Categories**
- **Hierarchies**
- **Abstractions**

<table>
<thead>
<tr>
<th>Tier</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Größe; Lebensraum; Tierart;</td>
<td>Size; Habitat; Species;</td>
</tr>
<tr>
<td>Essen(); Fortbewegen(); Schlafen();</td>
<td>Eat(); Move(); Sleep();</td>
</tr>
</tbody>
</table>

- **Class = Noun**
- **Attributes = Adjectives, Characteristics**
- **Methods = Verbs**
Languages

Biology

 Tier
Größe;
Lebensraum;
Tierart;
Essen();
Fortbewegen();
Schlafen();

Hund
Fellfarbe;
Art;
Fortbewegen(): Laufen;
Bellen();
Schnüffeln();

Katze
Fellfarbe;
Art;
Fortbewegen(): Laufen;
Klettern();
Jagen();
Schnurren();

Fisch
Schuppenfarbe;
Art;
Fortbewegen(): Schwimmen;
Unter Wasser atmen();

Wachhund
Name;
Besitzer;
Bewachen();
Spielen();
Sich streicheln lassen();

Löwe
Mähnengröße;
Faul im Schatten liegen();
brüllen();

Hauskatze
Name;
Besitzer;
Lieblingsplatz;
Spielen();
Sich streicheln lassen();

Goldfisch
Name;
Besitzer;
Lieblingsversteck im Aquarium;
Fortbewegen(): Im Kreis Schwimmen;
Chemistry

- Class & Object diagrams
- Classifying elements

Elementgruppe
- Gruppennummer
- Eigenschaften

Element
- Elementsymbol
- Ordnungszahl
- Gruppe
- Periode
- Atommasse
- Metallcharakter
- Aggregatzustand bei RT...

Halogene
- 7. Hauptgruppe
- reaktionsfreudige
- Nichtmetalle

Fluor
- F
- 9
- 7. Hauptgruppe
- 2. Periode
- 19 g/mol
- Nichtmetall
- gasförmig

Chlor
- Cl
- 17
- 7. Hauptgruppe
- 3. Periode
- 35,5 g/mol
- Nichtmetall
- gasförmig

...
Entity Relationship-Diagram

• Brainstorming
• Writing
• Summarizing
• Relations
• Vocabulary
• …

<table>
<thead>
<tr>
<th>Form and color</th>
<th>Computational expression / meaning / function</th>
<th>Used in the English foreign language as…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle: blue</td>
<td>Entity</td>
<td>Nouns</td>
</tr>
<tr>
<td>Rhombus: green</td>
<td>Relationship</td>
<td>Verbs</td>
</tr>
<tr>
<td>Ellipsis: yellow</td>
<td>Attributes</td>
<td>Attributes, such as adjectives, adverbs, and so on.</td>
</tr>
</tbody>
</table>

Notation of ER-diagrams in English as foreign language [13]
Tell a story!

Sample ER-diagram “Tell a story!” used in a unit for kindergarten [14]
Use case diagrams

- Situations
- Events
- Actors
- Activities
- Theater
- Film plot
- ...

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Computational Thinking & Modeling for Everyone
Results: Acceptance

• Acceptance  
  (interviews, observation, discussion, questionnaires)
  
  • Useful tool in different subjects for
    • Representing and structuring information and knowledge
    • Preparation of presentations (cheat sheets)
  
  • Can foster creativity
  • Helps to extract important information
  • Fun
  • Generalization is difficult (for teachers and students)
  • Why not mindmaps? [13]
Acceptione

Satisfaction Flow charts & ER-diagrams in English as foreign language
(1 very high – 3 low)

\( N_{Flow} = 71, \ N_{ER} = 70 \) [15]
Practicability & Usability

Use in future learning situations

- Yes: 40%
- Maybe: 22%
- No: 17%
- No answer: 21%

N = 85 (grades 5-8) Modeling in English as foreign language [15]
Results: Comprehension

• Teacher & student opinion
  • Easy to understand
  • Difficult to apply
  • Uncertainty concerning CS criteria

• Problems and Challenges
  • Abstraction difficult\(^1\)
  • Relation and entity in one shape\(^2\)
  • Incorrect or missing attributes
Modeling Priorities & Criteria

Teaching CT or CS

• Adequate use of
  • diagrams
  • shapes
  • relations
• Abstractions
• Branches
• Attributes
• Logical

Learning strategy

• Subject-specific contents correct
• Essential information available
• Useful
• Adequate use of
  • diagrams
  • relations
Conclusion & Outlook

• Modeling & Computational Thinking (CT)
  • Useful in all subjects, especially languages
  • Basics easy to learn and apply
  • Teaching in 2 steps:
    1. correct shapes
    2. abstraction, generalization
  • Clear priorities: CT or learning strategy
  • Sample materials needed

• Modeling across the subjects
  • Erasmus+ Key Action 2 Strategic Partnership
  • Further studies in different subjects needed:
    • text comprehension & extraction of core information
    • generalization and abstraction
    • effect of different concepts for different purposes
JKU COOL Lab

• **Informatics Lab** (all visitors > 4 years)
  • Increasing interest and comprehension in *computer science*
  • Projects: CSI Informatics, game design, etc.
  • Weekly (Friday 14:00) and summer lab (July 9-20)

• **Teaching-Learning-Lab** (students, teachers & docents)
  • Interweaving *teacher pre- and in-service training* with practice
  • *Computational thinking & digital literacy*
  • Innovative and effective *teaching and learning methods* for
  • Primary, secondary and higher education

• **COOL Talents Club** (grades 5-9)
  • Promoting young *talents in STEM*
  • *Interdisciplinary* projects
Thank you!

Questions?

Discussion!

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References


