Self-directed learning and computational thinking in Finnish chemistry education context

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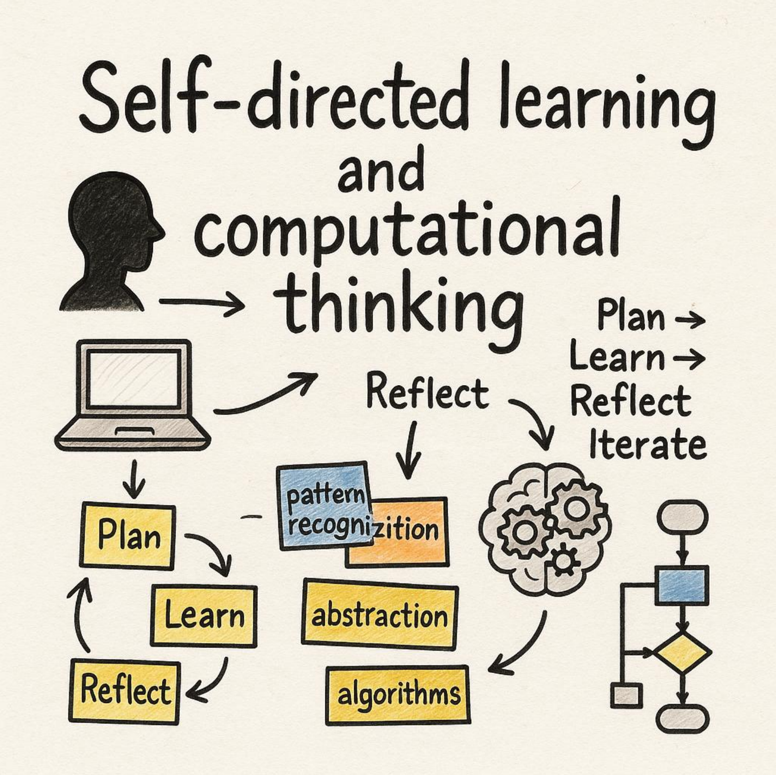

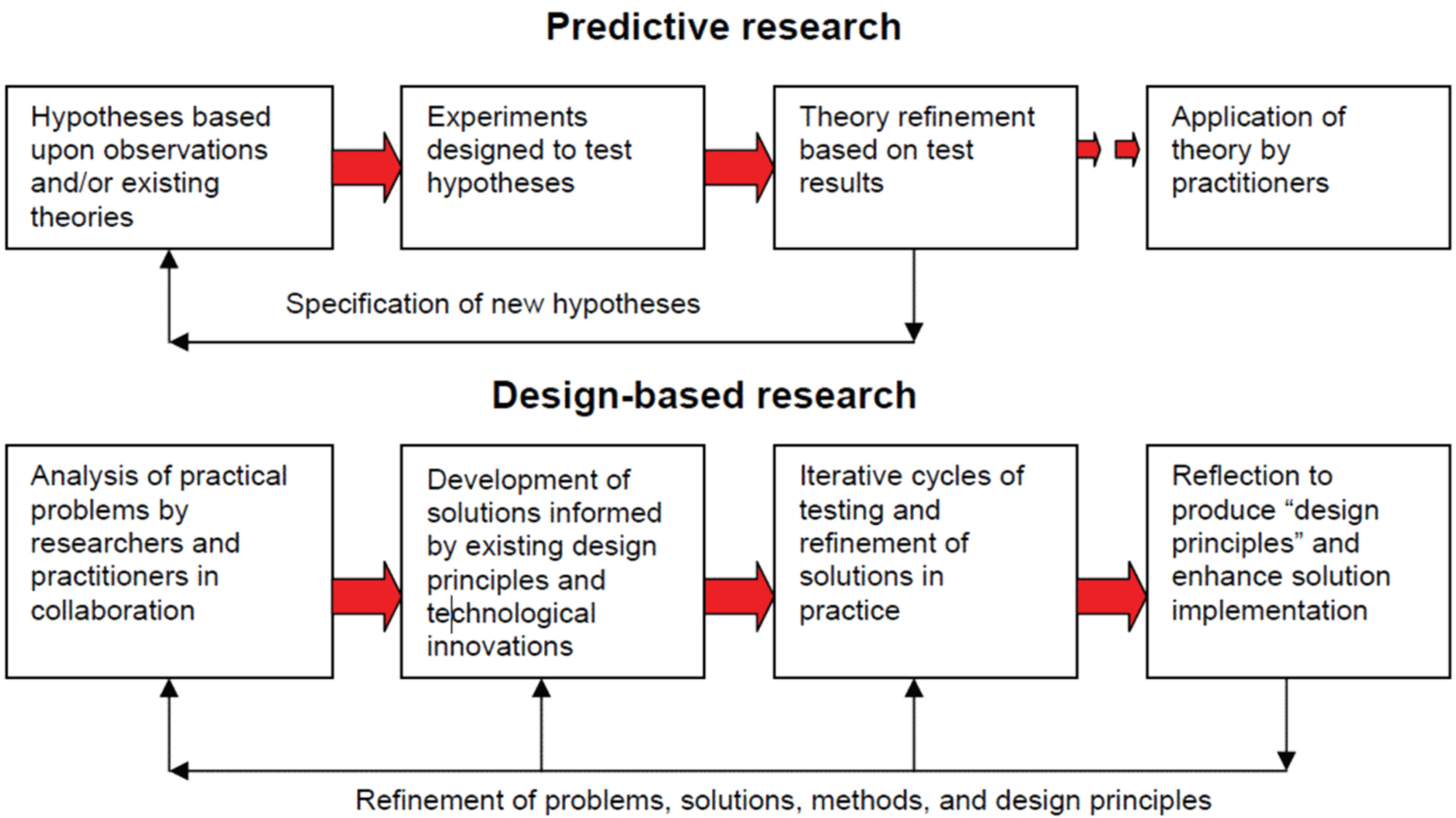

Figure 1. Model of Design-Based Research (Amiel & Reeves, 2008)

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Self Study:
Chemistry education in transformation

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Different projects – Innovations for chemistry education:

- **Open and share new initiatives** by make these ideas transparent and visible
- **Testing new methods and creating materials and guides** for myself and other teachers

Current practises versus new innovations?

- Advanced use of digital tools and applications does not mean only the use modern educational technology → **Scientific practices**
- Traditional teaching methods → Combining computational thinking and modern approach to pedagogy (includes SDL), modelling (understanding Johnstone triangle)
- Divide and share information vs. Increasing Curiosity -based approach (Knowles)
- Teaching materials, which are still based on traditional thinking and memorizing, and earlier adopted studying methods → Interactive and editable teaching materials, and then use of AI

→ new level of chemistry education – what is engaging me and fulfilling my interest!


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Scientific Practices

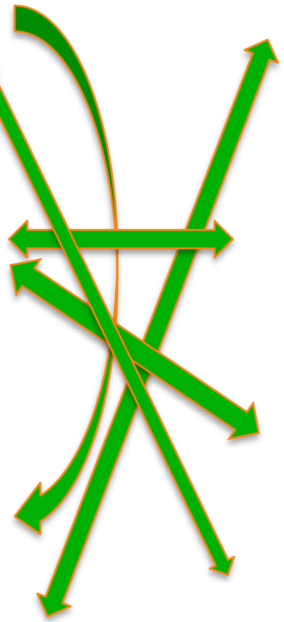
The multiple ways of knowing and doing that scientists use to study the natural world and design world.

1. Asking questions and defining problems

2. Developing and using models

3. Planning and carrying out investigations and designing solutions

4. Analyzing and interpreting data



5. Using mathematics and computational thinking

6. Constructing explanations and designing solutions

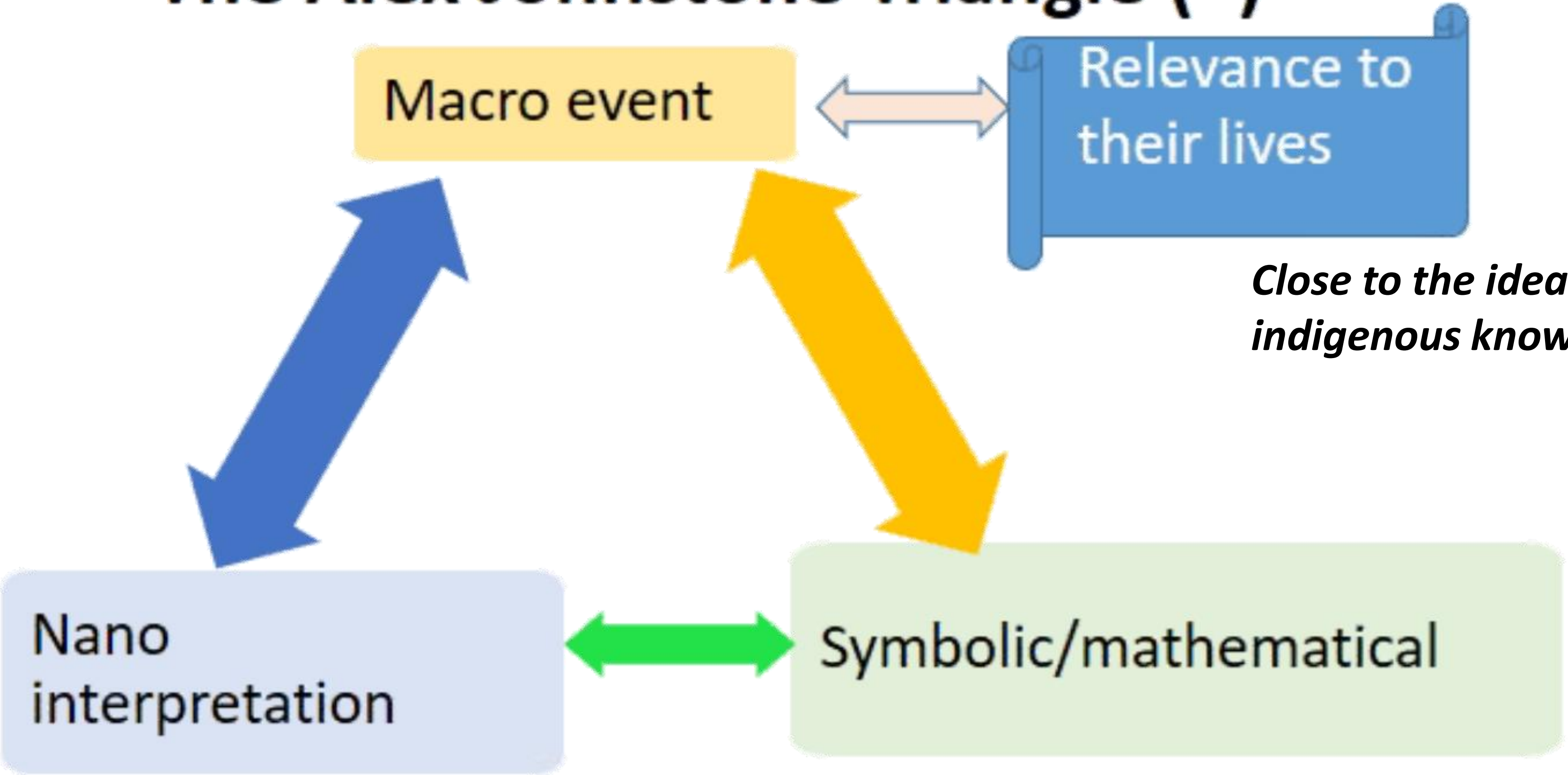
7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

The practices work together – they are not separated!

Important framework to understand chemistry education

The Alex Johnstone Triangle (+)



Close to the idea of indigenous knowledge

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→new level of chemistry education, understanding that:

adopting innovative pedagogies with technology requires teachers to go through a **“process of redoing and rethinking”**, which can be an enormous challenge (Fullan)

Self-directed learning in Finnish context

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Understanding the difference between self-directed and self-regulated learning?

- **Self-Directed Learning (SDL):**
  - SDL refers to a **learner's initiative in diagnosing their own learning needs**, setting goals, identifying resources, and evaluating their learning outcomes.
  - It emphasizes autonomy and personal responsibility in the learning process, allowing **learners to take charge of their educational journeys**.
- **Self-Regulated Learning (SRL):**
  - SRL involves a **self-directed process where learners actively manage their learning** through goal setting, self-monitoring, and self-reflection.
  - It focuses on **the strategies employed during the learning process**, including metacognitive skills that help learners adapt their approaches based on feedback and self-assessment.

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Pedagogical debate in Finland

- In Finnish pedagogical discussions you can find many paradigmatic positions (excluding not including different approaches)
- Flipped learning/ flipped classroom approach (one of the Finnish interpretation of SDL) vs. Traditional teaching
  - Flipped learning’s roots are intertwined with the self-directed learning theory articulated by Knowles, but its specific instructional format was developed decades later by educators seeking to implement these ideas in practice through a structured, technology-supported classroom approach.
- Pedagogy first vs. Technology first → Entangled pedagogy (Faws)
  - More than TPACK (Shulman and Koehler, Mistra)
  - Since technology is entangled within pedagogy, it is not possible to first choose a pedagogy and then a technology, nor can pedagogy be tacked onto an existing instantiation of technology. Placing pedagogy above technology does not imply pedagogical determinism because teachers and educational designers have only partial and relational agency.
- Problem based learning (inquiry based learning) vs. Traditional teaching and learning
  - Problem-Based Learning (PBL), not only increases students’ motivation, but it also leads them beyond memorisation to develop a deeper understanding of the subject matter

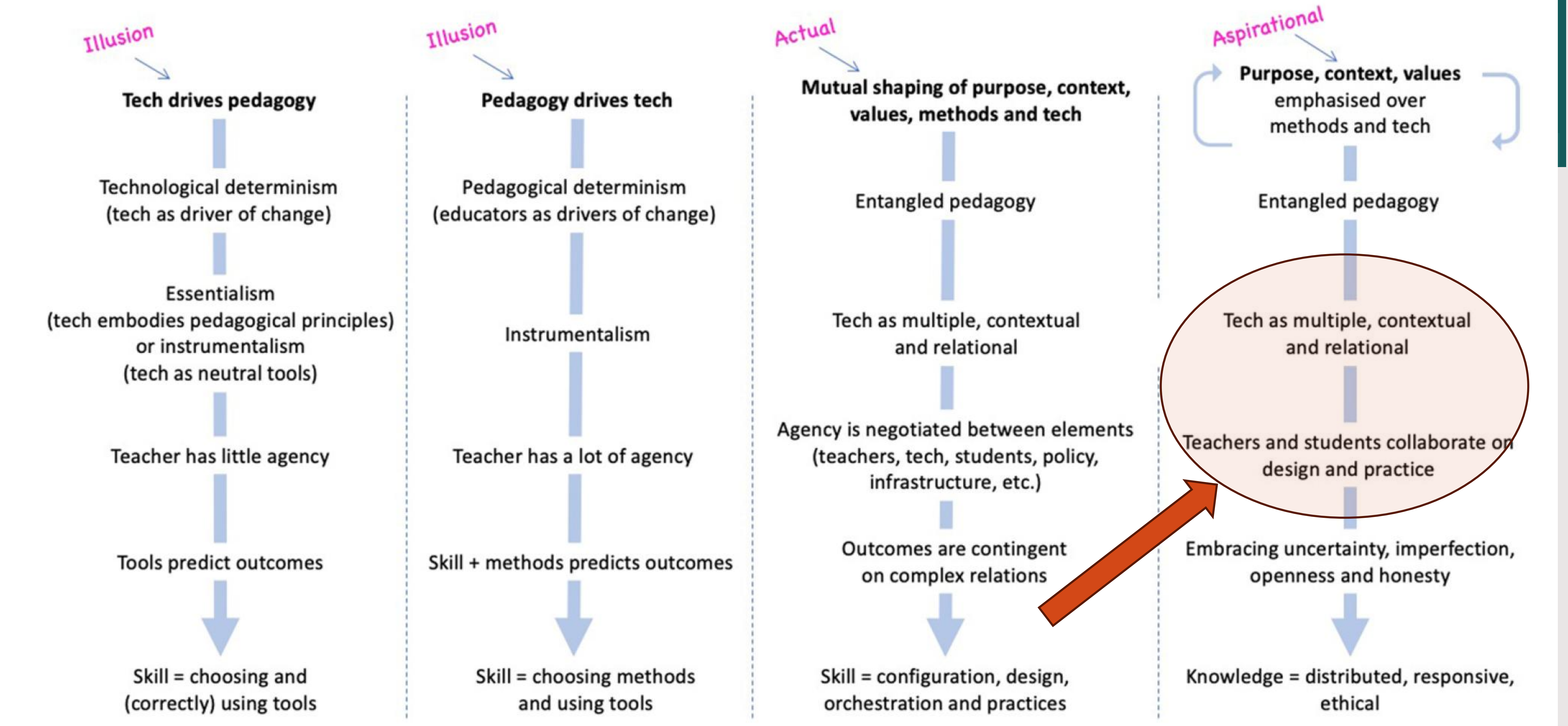

Fig. 2 An entangled pedagogy, including an aspirational view

Similarities between SDL and Flipped Learning approaches

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Encourage students to **take ownership of their learning** by preparing on their own before class

Flipped learning **requires students to engage with instructional resources independently**, thereby fostering self-directed learning abilities

In-class time used for **interactive, collaborative activities** (such as discussion, problem-solving, or group projects)

Teachers shift from being primary content deliverers to facilitators or guides, **supporting and assisting learners in their independent and group activities**.

The flipped classroom can act as a **vehicle for self-directed learning**, leveraging pre-class preparation and active, in-class engagement for skill development.

Computational thinking in Finnish context


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Valerie Shute and colleagues (2017) delineated **six key facets of computational thinking** (CT):

- decomposition
- abstraction
- algorithm design
- debugging
- iteration
- generalization

These facets provide a **structured framework for problem-solving** and can be effectively integrated with self-directed learning (SDL) to enhance students' autonomy and metacognitive skills.

Each CT facet aligns with specific SDL strategies, fostering a comprehensive learning approach

Cognition with CT and SDL


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Cognition refers to mental processes related to thinking, such as comprehension, memory and problem solving.

CT gives tools for **different processes** (for example algorithmic thinking, finding similarities and patterns, decomposition, abstraction)

When cognition is developed in **SDL**, the goal is for learners to **process information and solve problems independently and effectively**. Modern way to teach focus on deep learning, social interaction and understanding of the relevance of activity **instead of memorisation and passive listening**.

Metacognition with CT and SDL


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Metacognition is the awareness and understanding of one's own thinking processes. It involves reflecting, evaluating and regulating one's own learning.

CT follows the idea of **reflection and feed-forward style feedback** (testing and debugging, iteration, generalization).

Developing metacognition in SDL means that students **learn to examine their own thinking**, **to plan and monitor their own learning and to assess their progress**. In this way, they become more independent learners.

Computational thinking in high school chemistry

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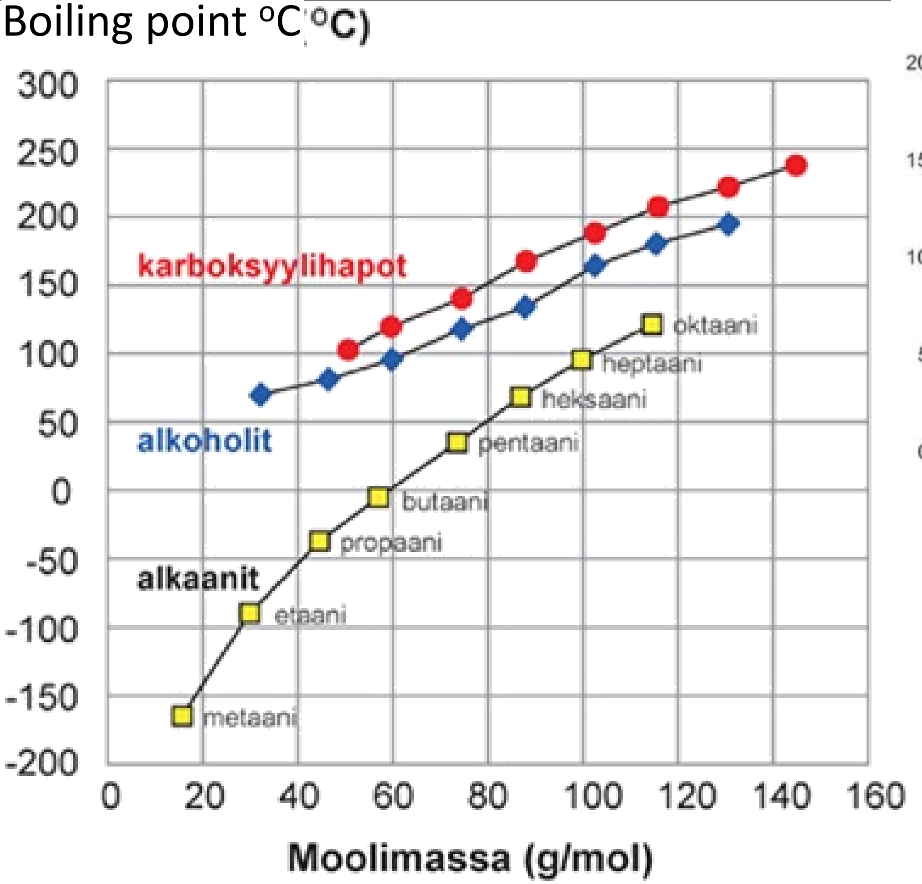
Shute (2017) has defined **six facets** within the Computational Thinking concept

1. decomposition; the whole consists of parts
2. summarizing information, collecting and analyzing information, finding consistencies (patterns) and modeling;
3. algorithmic thinking, design of algorithms;
4. debugging;
5. iteration and
6. generalization.

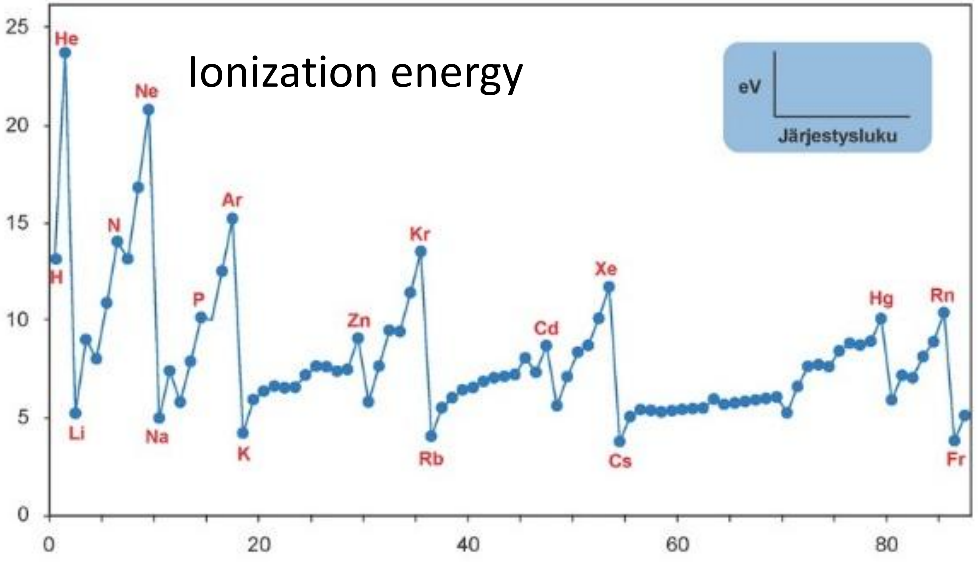
Computational thinking approach IS TO GIVE TOOLS how WORK WITH the information and data → Increasing autonomy (and self-directed learning) instead of memorising issues.

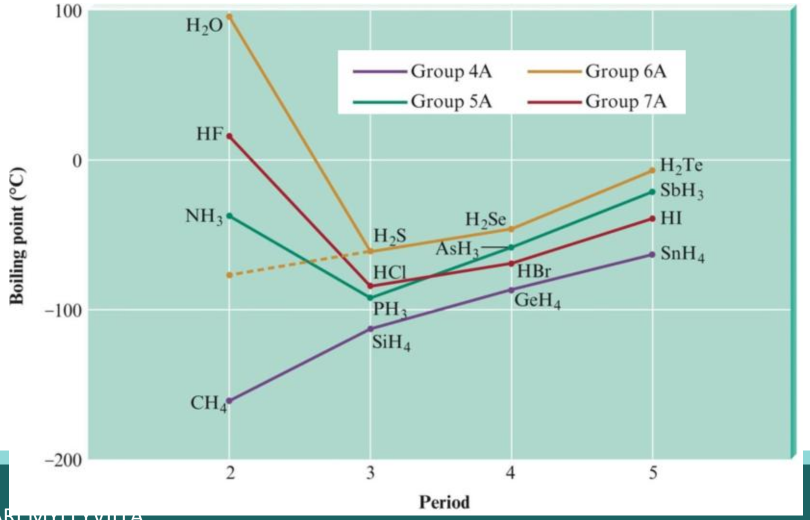
Different kind of patterns in chemistry (Analysing information)

Boiling point °C



Ionization energy

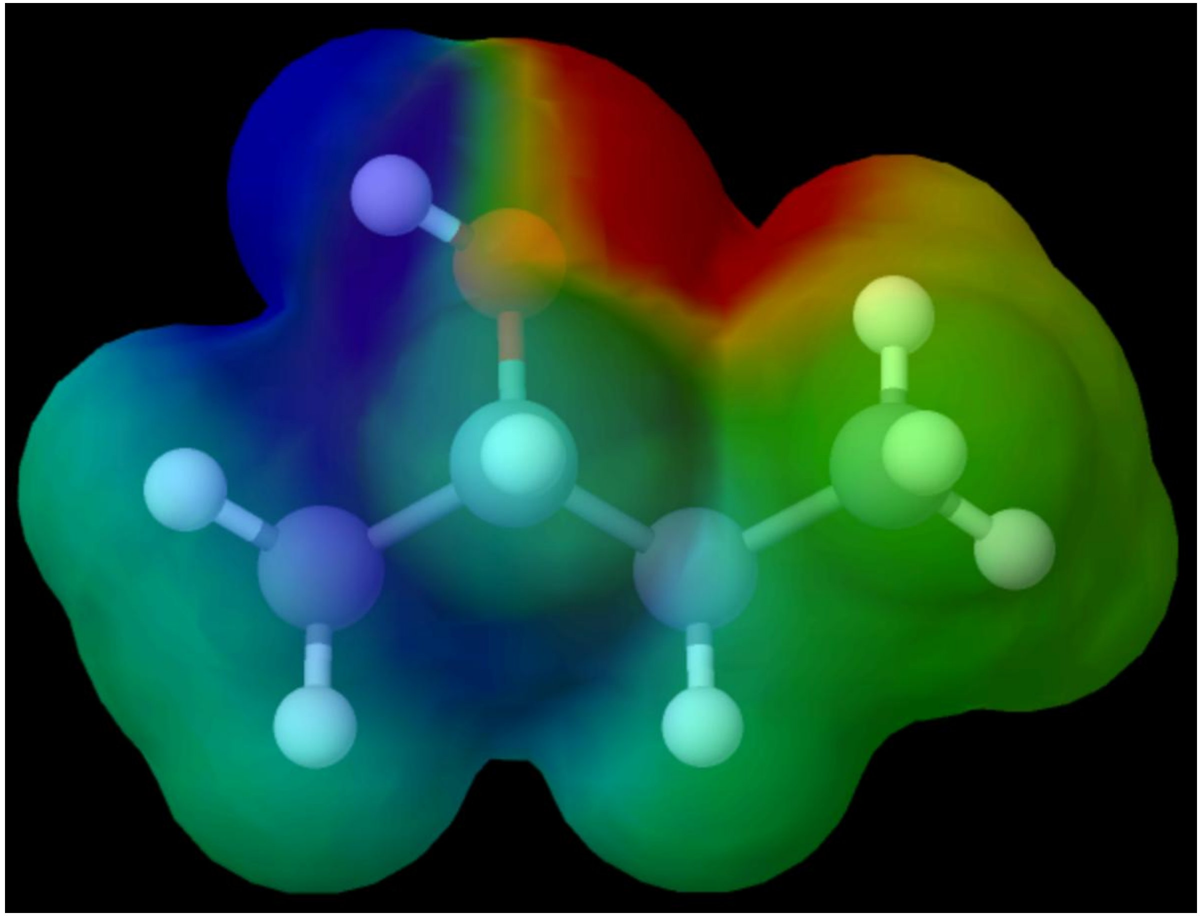




Modeling – 3D-approach of weak bonds

Concepts:

- Electron density
- Electronegativity
- Polar molecules
- Weak bonds



Using 3D-modeling programs – Electronegativity differencies?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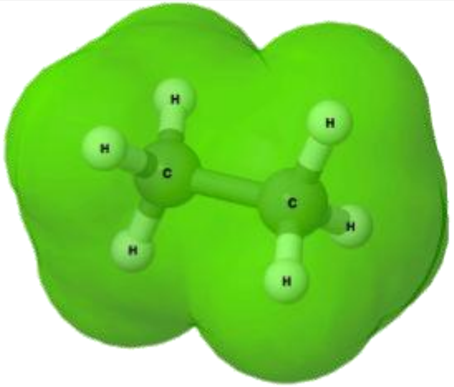
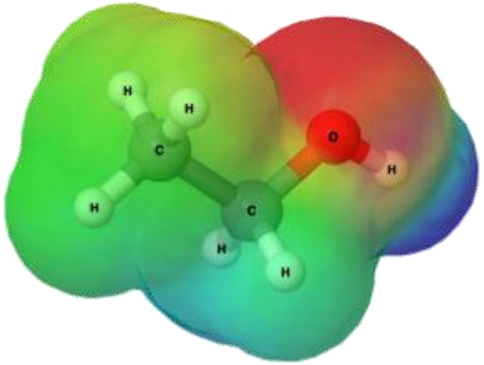
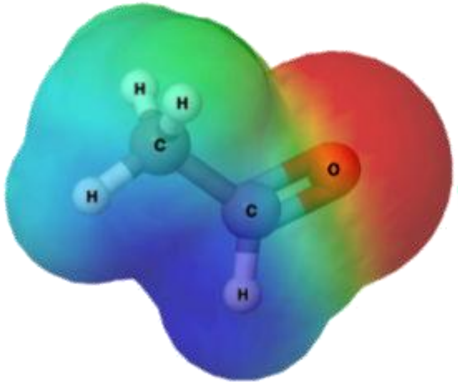
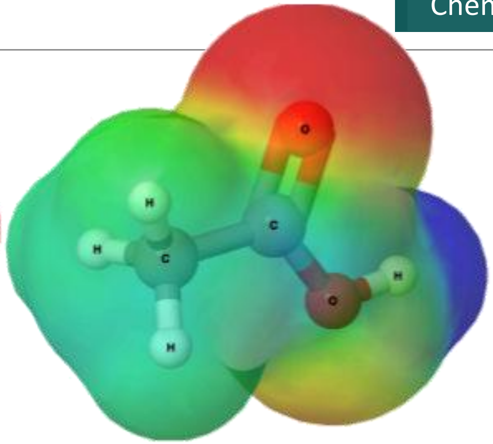
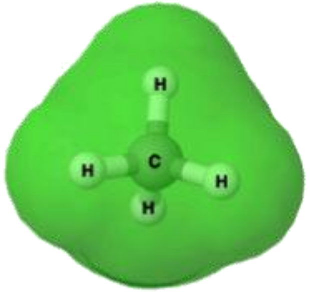
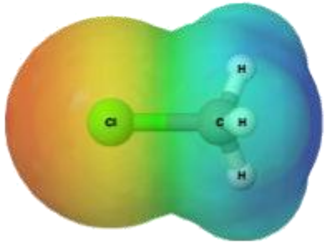

Ethane

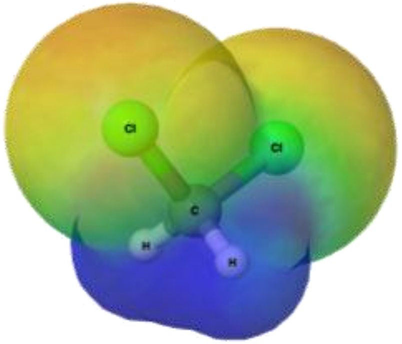

Ethanol

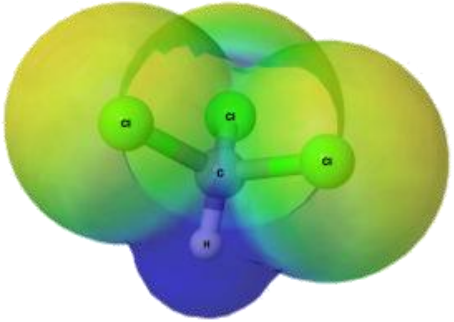

Ethanal

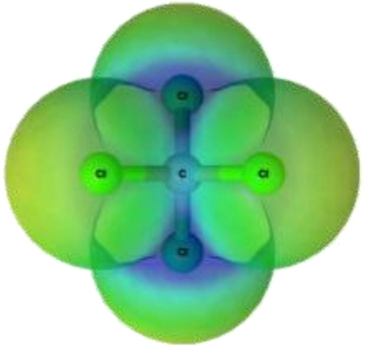

Ethan acid


Methane



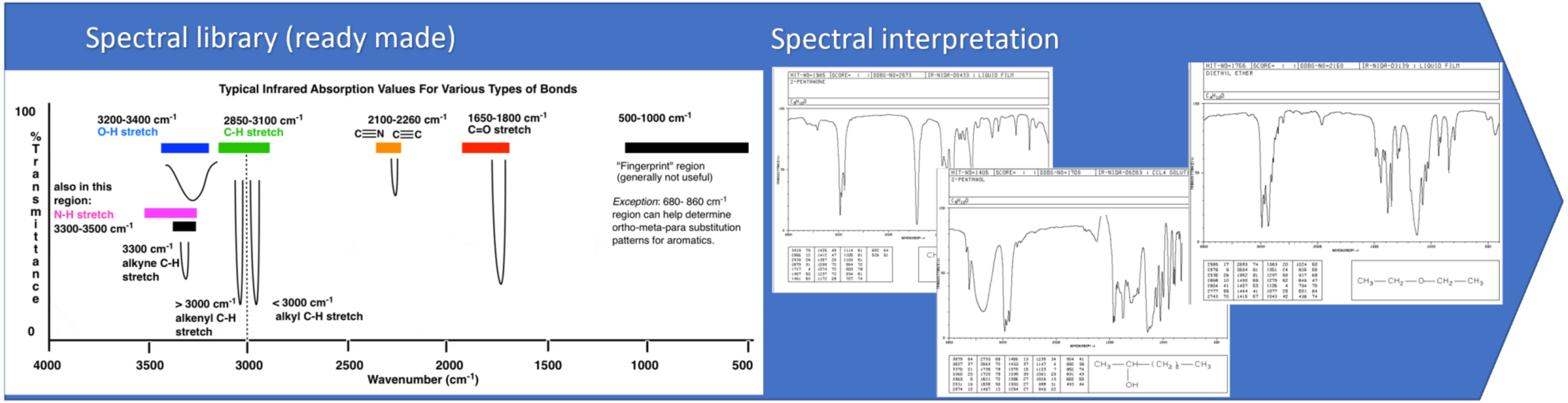




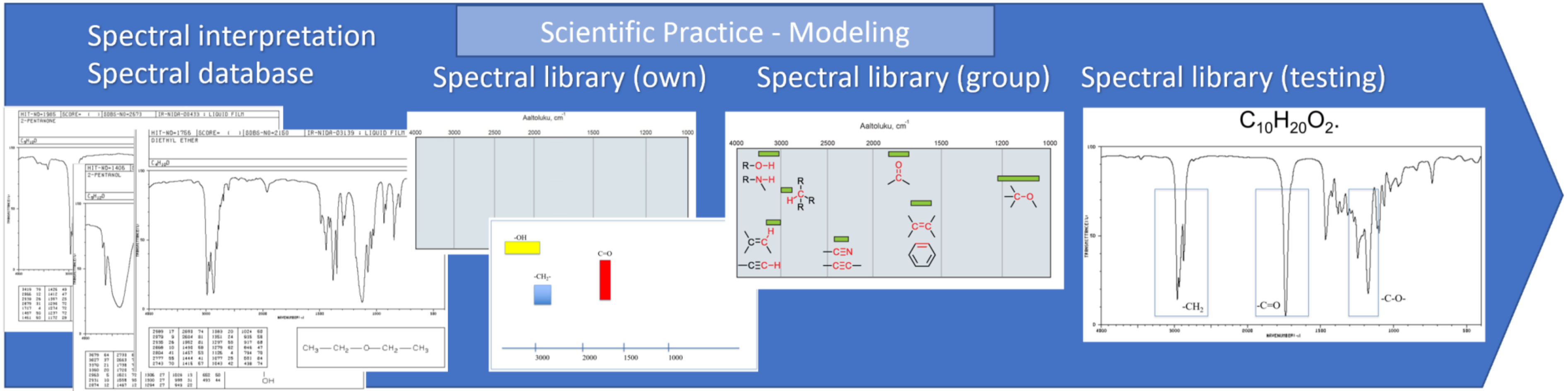

Tetracloromethane

Teaching Spectroscopy (Desing algorithms)

Traditional



Modeling – Algorithmic thinking



Results and conclusions

- Computational thinking into core curricula (upper secondary school) like certain aspects of self-directed learning.
- Finnish teachers and students need to acquire new conceptual understanding and skills.
- Advanced use of digital tools and applications → use of such digital practices that are authentic
- Combining computational thinking, scientific practice and modern approach to pedagogy (like SDL) we´ll find a new level of chemistry education
- The problem is our teaching materials, they are still based on traditional thinking and memorizing, and other earlier adopted studying methods
- It is important to open and share new initiatives by make these ideas transparent and visible using self-study research approach.
- Testing new methods and creating materials and guides for myself and other teachers is important task for me as a teacher educator.

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Some references

Fawns, T. (2022). An entangled pedagogy: Looking beyond the pedagogy–technology dichotomy. Postdigital Science and Education, 4(3), 711–728. https://doi.org/10.1007/s42438-022-00302-7

Juuti, K., & Lavonen, J. (2021). Curriculum Development in Science. In Zoi A. Philippakos, Emily Howell, and Anthony Pellegrino (Eds.), Design-Based Research in Education Theory and Applications. Guilford.

Koehler, M. J., & Mishra, P. (2008). Introducing TPACK. In AACTE Committee on Innovation & Technology (Eds.), Handbook of technological pedagogical content knowledge for educators (pp. 3–29). New York, NY: Routledge.

Krajcik, J., & Shin, N. (2015). Project-based learning. In K. Sawyer (Ed.), The Cambridge handbook of the learning sciences (2nd ed., pp. 275–297). Cambridge University Press

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. Educational Research Review, 22, 142-158. https://doi.org/https://doi.org/10.1016/j.edurev.2017.09.003

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Thank You!

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