A Research-driven View on Science Teacher Education

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Different understanding of a quality outcome of a science teacher education programme …

- A qulaity outcome could be called, for example, a *professional* or an *effective teacher*, which are both complex and contradictory concepts *(Cruickshank & Haefele, 2001; Stronge & Hindman, 2003; Goe, Bell & Little, 2008)*

  Instead of a professional/effective a "competent", an "expert", a "quality", an "ideal" or a "respective" are used

The definitions are not only characteristics of teachers, but include support by
- the national and
- local administration and
- the school site

The "*professional teacher*" act as an autonomous expert while planning, implementing and assessing teaching and students' learning

Effectiveness of the "*effective teacher*" is seen in the learning outcomes, measured e.g. by national tests.

Content of the presentation

Coherent science instruction

Coherent teacher education

Learning of transversal competences as a part of Science teacher education

Summarising coherent science and science teacher education

Coherent science instruction

[1]*National Academy of Science, Engineering, and Mathematics [NASEM], 2018*

Several science education reforms have been implemented in line with the research on science learning[1], such as:

- *constructivist teaching* (e.g., Haney & McArthur, 2002).
- *reform-based* (e.g., Veal et al., 2016),
- *inquiry-based* (e.g., Furtak et al., 2012) , and
- *project-based-learning* (Krajcik & Shin, 2014).

Some outcomes of research on science learning:

students' misconceptions

Meaning making

Preconceptions: Prior ideas about how things work influence learning.

Knowledge organization: students should have a deep foundation of conceptual knowledge in order to organize knowledge, facilitate retrieval and use of knowledge.

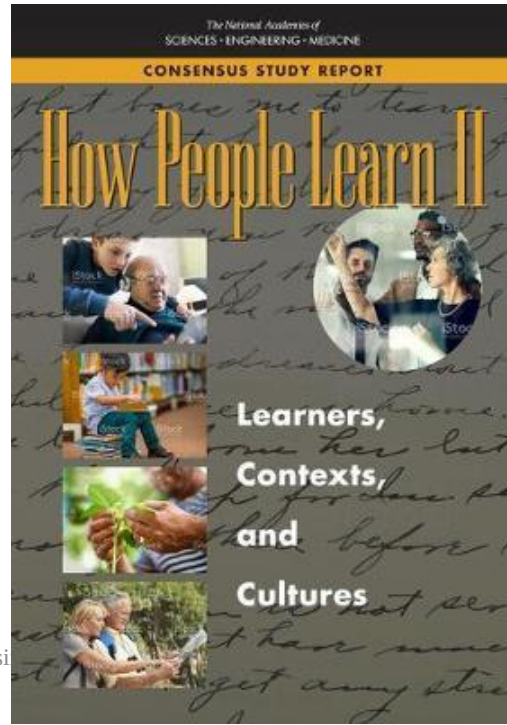
Metacognition: Students benefit from thinking about their learning. They must be taught to evaluate their learning and knowledge, …

Motivation, interest, engagement, self-efficacy (…) influence learning and well-being, guide academic and career trajectories, …

Social interaction plays a fundamental role in the development of cognition

Role of **contexts** from the point of view of learning and engagement

Role of **artefacts** in learning



Meaning making

One of the “new reforms” is coherent science instruction

Crosscutting concepts across STEM field,

STEM practices

STEM context: learning & engagement

Interdisciplinary STEM PBL

- focus to the learning of **core ideas** (key concepts) over a long period of time (Alonzo & Gotwals, 2012; Fortus & Krajcik, 2012; Kali et al., 2008; National Research Council, 2012)
- connect of learning of core ideas and **scientific & engineering practices** (science process skills) (Sikorski & Hammer, 2017)
- **contextualization** of learning around relevant phenomena and meaningful problems (NASEM, 2019)
- students **make sense of phenomena** through engaging in practices, collaboration and constructing of artefacts (Furtak & Penuel, 2019; Lee & Songer, 2003; Schneider et al., 2020)
- **teacher scaffold** students’ learning processes: *only a teacher knows how intended curriculum is enacted, and learning supported through appropriate pedagogy* (Penuel & Gallagher, 2009; Wilson et al., 2018).

What is known about coherent science instruction?

- Coherent instruction support students'
  - learning,
  - motivation and engagement in learning, and
  - equity

  better than traditional approaches (Beier et al., 2018; Geier et al., 2008; Harris et al., 2015; OECD, 2016; Schneider et al., 2020).
- The importance of coherence is reflected in science curriculum documents (e.g., KMK [Sekretariat der Ständigen Konferenz der Kultusminister der Bundesrepublik Deutschland], 2005; NGSS Lead States, 2013; Vahtivuori-Hänninen et al., 2014)
- New teachers struggle to implement the pedagogical tools and strategies they learned within preservice science teacher education and easily adopt more traditional instructional, and les coherent, approaches in their own teaching (Fulton et al., 2005; Roehrig & Luft, 2004)

Coherent teacher education

Some outcomes of the research on teachers and teacher education in various contexts
(Husu & Toom, 2017)

COHERENT SCIENCE INSTRUCTION

COHERENCE OF THE PROGRAM

DOMAINS AND ORIGINS OF TEACHER KNOWLEDGE

TEACHERS' PROFESSI-ONAL LEARNING

- In addition to emphasis to coherent science instruction, …
- General coherence in teacher education
  - shared understanding of the aims of the program
  - coherence between field experience and courses
- Pedagogy in line with the aims of the program: learning of domains of teacher knowledge from lectures/workshops/books and from practice
- Teachers should be willing and able to learn continuously new competences, coming from the research and needs of the society.

Teacher knowledge from the point of view of research on classroom interaction and learning

(Hattie ja Jaeger, 2003; Hattie, 2012; Lonka, Hakkarainen, Lakkala, 2010; Kereluik et al., 2013)

SUPPORTIVE PEDAGOGY for LEARNING

- Support to the learners in integration of knowledge to previous knowledge through employing good pedagogy, such as project based learning (PBL)

INTERACTION

- Guiding learning through classroom interaction

FEEDBACK

- Monitoring learning and giving feedback

INTEREST ⇳ LEARNING

- Taking into account interest and motivation dimensions supportive for learning. Providing suitable challenges for learners. Passionate attitude towards teaching and learning.

SELF-REGULATION

- Emphasize learning of self-regulation skills and development of self-confidence and self-esteem.

Domains of teacher knowledge

(Shulman 1986, 1987; Gess-Newsome & Lederman, 1999; Hashweh, 2005)

A professional teacher has a versatile knowledge base, which allow him or her to act as a professional.

Classical knowledge base consists:

- subject matter knowledge,
- pedagogical content knowledge PCK,
- pedagogical knowledge,
- contextual knowledge,
- curriculum knowledge,
- …
- community knowledge

… *WHAT ELSE?*

Pedagogical content knowledge (PCK)

Grossman, 1990; Bromme, 1995; Hashweh, 2005; McCaughtry, 2005; Nilsson, 2008

Teacher's personal PCK (pPCK) serves as a knowledge base that a teacher draw upon when designing and enacting instruction

Collective PCK (cPCK), which represents a shared knowledge base among a community of science teaching professionals (e.g., teachers, researchers).

- PCK is a knowledge domain that is a synthesis of all knowledge needed for teaching and learning a specific topic:

- PCK is
  - topic specific,
  - event- and story-based pedagogical construction a teacher has developed

  as a result of repeated
  - planning and teaching and
  - **collaborative** reflection on the teaching of the most regularly taught topics.

  PCK is an intentional act

The Content Representation (CoRe) tool

- tool for structuring pedagogical content knowledge (PCK) in order to make instruction coherent

(Loughran, Mulhall & Berry, 2004)

Across STEM field

- What do you want students to learn about the topic or what are the **core ideas**/big ideas/key concepts and models of the topic?

STEM context

- Why it is important (**meaningful and relevant**) for students to learn this topic (need-to-know)?
- What else do you know about this topic - not going to teach students (the level of scientific content)?

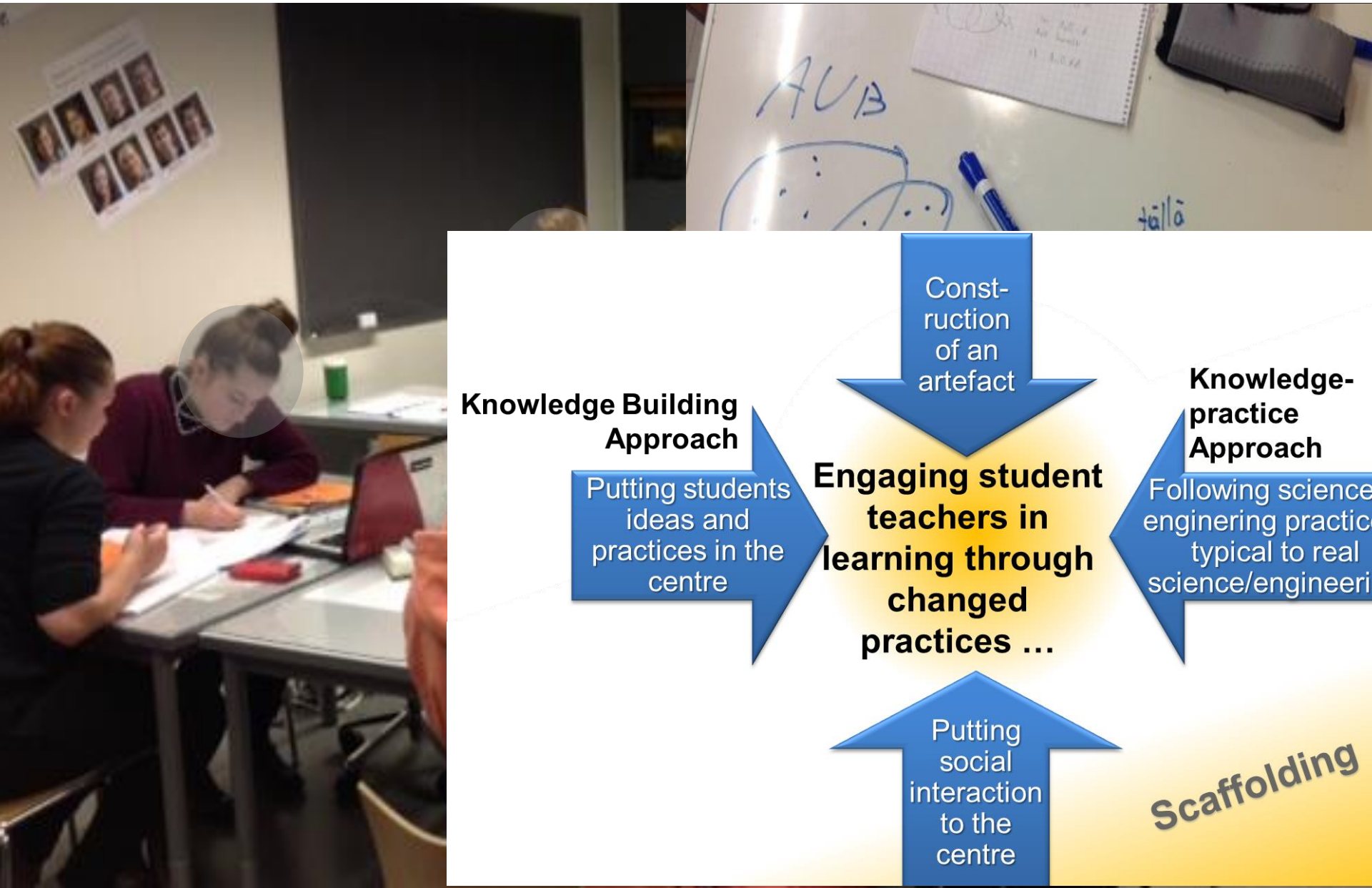
STEM experiences

- What do you know about students' everyday experiences in the area of the topic?
- What do you know about students' conceptions/ **misconceptions** related to the topic and how does it affect the teaching of the topic?
- How **context** influences the teaching of this topic? (student, classroom and school context).

Interdisciplinary STEM PBL

- What **teaching methods** do you intend to use to teach the topic, and how well the method suited for teaching the topic? (Knowledge-in-use)?
- How are you going to **evaluate** student learning (knowledge-in-use)?

Pedagogy, supportive for the learning of subject matter and PCK



Learning of transversal competences as a part of Science teacher education

According to OECD 14% of the current (2018) jobs will be highly automatised and 32% of the current jobs face sustainable change OECD PIAAC -study

http://www.oecd.org/employment/Automation-policy-brief-2018.pdf

47% of the current jobs will vanish in the next 25 years

(Oxford University)

New jobs appear - we do not yet know them

https://bigthink.com/philip-perry/47-of-jobs-in-the-next-25-years-will-disappear-according-to-oxford-university

Are our science
- teacher education programmes and
- teacher educators
ready for educating science teachers who are able to support the next generation learn competences needed in labor market?

Several frameworks for 21st century competences / transversal or generic competences

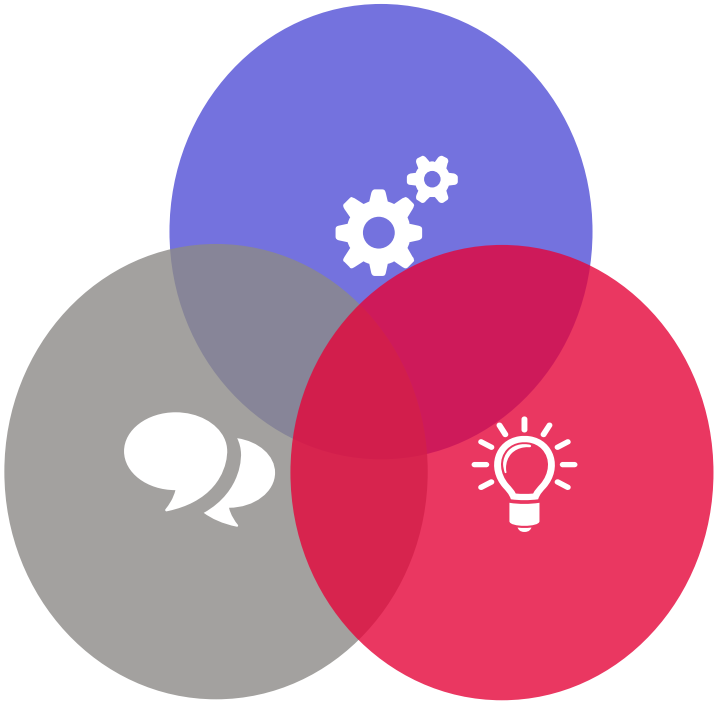
Organization and Year	Terminology and connotations (Competence /knowledge/skills/attitude/values for different purposes)
UNESCO (Universal Learning) 2013	What learning is important for all children and youth for the 21st century *for good life*
EU (Lifelong learning, 8 key competences) 2006; 2018 (update)	Competences (knowledge, skills, and attitudes) needed *for personal fulfilment*, active citizenship, social inclusion and *employment*
OECD Future of Education and Skills 2030	Practical and physical skills; cognitive and meta-cognitive skills, social and emotional skills

What competences should be emphasised in education according to OECD learning compass 2030 ?

Basic competences

Know-what (*concepts, principles, processes*)
and know-how
(*inquiry, problem-solving, design solutions*)

Social and emotional skills:
empathy, self-efficacy, responsibility and collaboration

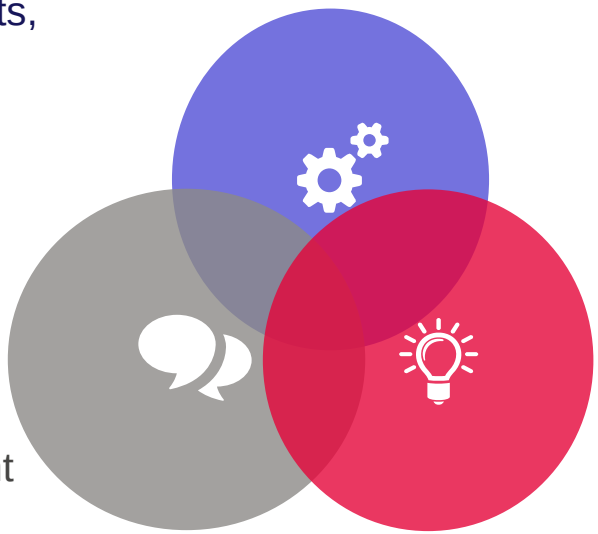


Cognitive and meta-cognitive skills:
critical and creative thinking, learning-to-learn and self-regulation

Interpreting teacher competences in the context of OECD learning compass 2030

professional knowledge and practices:

- knowledge about students and how they learn
- knowledge about content and how to teach it
- planning, assessment and reflection skills,
- skills for acting in various digital and physical learning environments,



Social and emotional skills:

- empathy, self-efficacy,
- interaction and collaboration skills
- skills for collaborating in different networks and partnerships

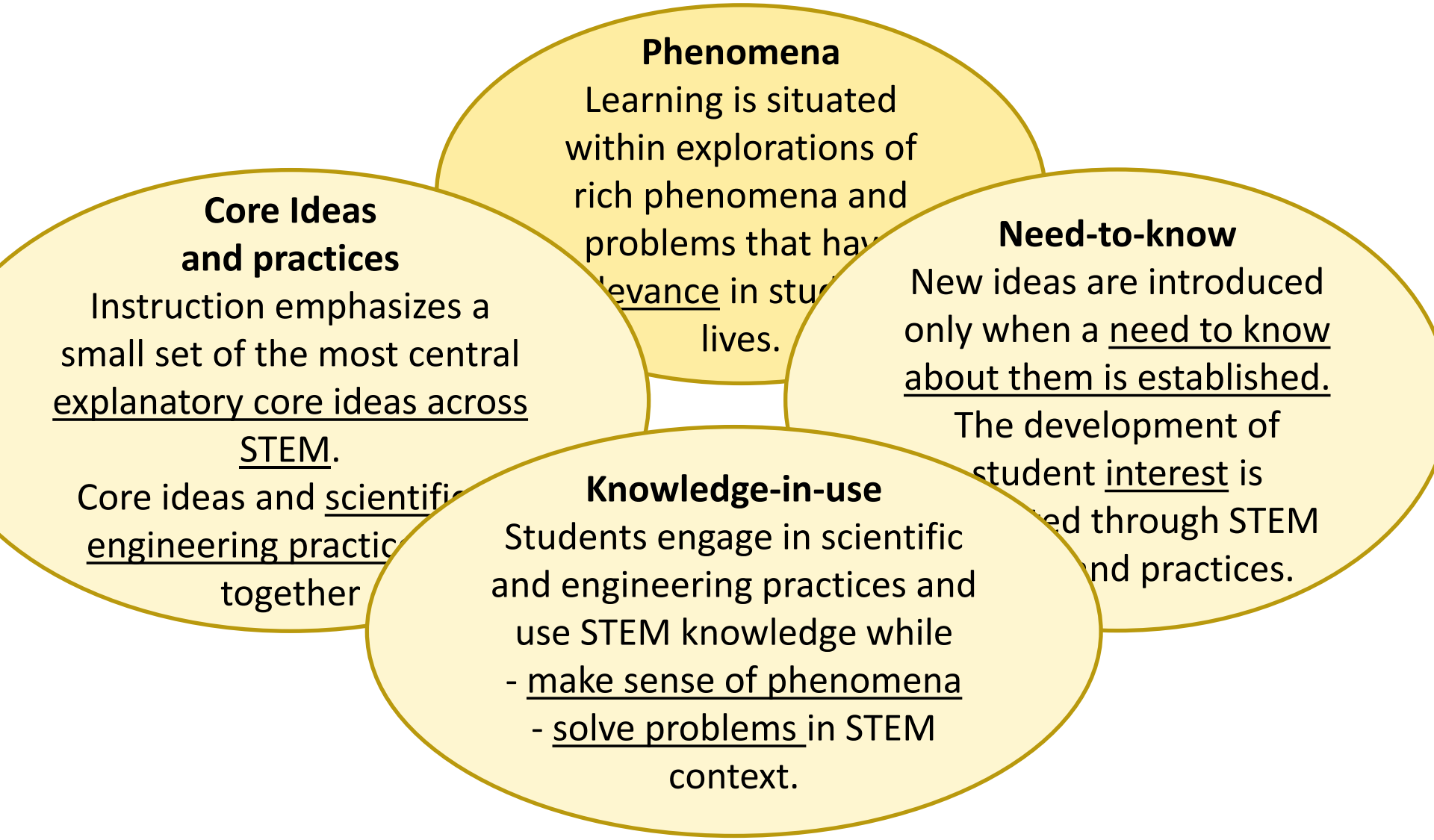
Cognitive and meta-cognitive skills:

- research skills,
- skills for generating ideas and pedagogical innovations,
- skills for developing teachers' own expertise and school environment

https://www.oecd.org/education/2030-project/teaching-and-learning/learning/skills/Skills_for_2030_concept_note.pdf

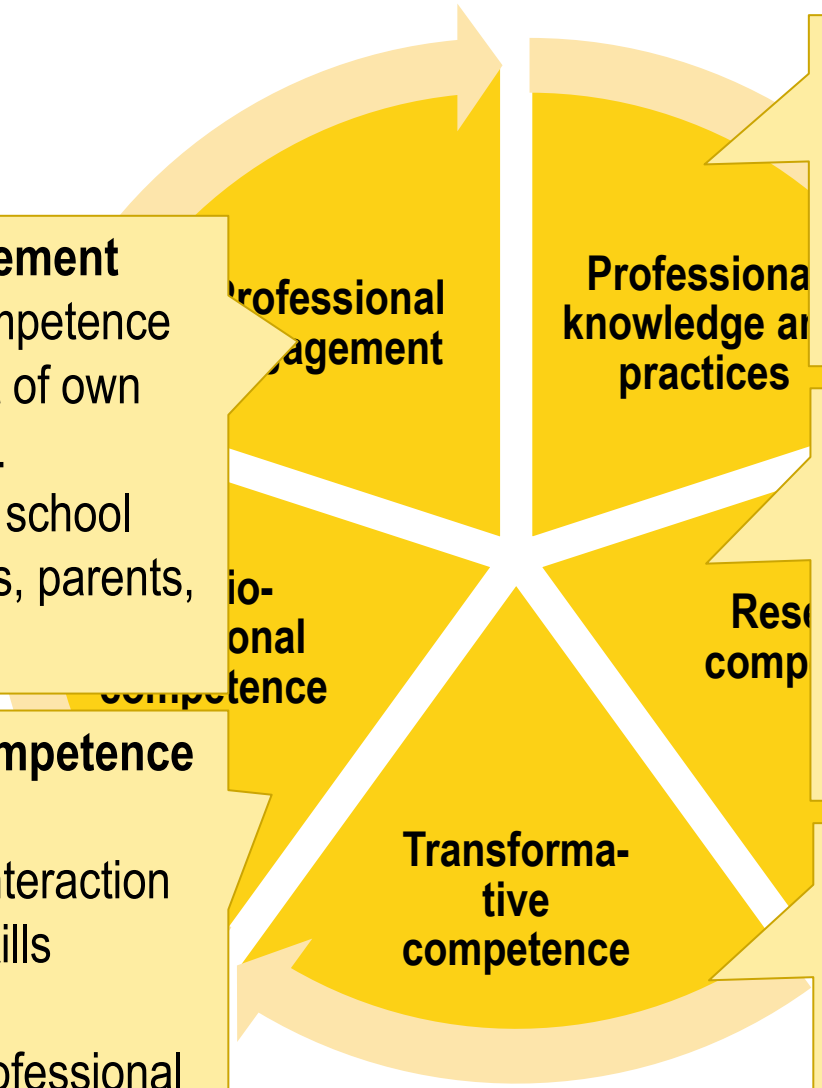
Summarising coherent science and science teacher education

Characteristics of coherent science instruction



Nordine, J., Sorge, S., Delen, I., Evans, R., Juuti, K., Lavonen, J., Nilsson, P., Ropohl, M., & Stadler, M. (2021). Promoting Coherent Science Instruction through Coherent Science Teacher Education: A Model Framework for Program Design. *Journal of Science Teacher Education.* https://doi.org/10.1080/1046560X.2021.1902631

Aims for coherent teacher education



Professional knowledge in
- Subject matter, PCK, GPK, …
- Learning, engagement, diversities,
- Ethics and society relations …

Professional engagement
- Willingness and competence for the development of own expertise through …
- Development of the school culture with students, parents, and stakeholders.

Research competence
- Critical thinking skills and producing of research based knowledge
- Consuming of research based knowledge

Socio-emotional competence
- Empathy
- Collaboration and interaction skills, networking skills
- Self-efficacy
- Responsibility or professional ideology

Transformative competence
- Creative thinking skills and innovative orientation
- Design of curriculum and learning environments

Design of a coherent teacher education programme

Research on subject area and on teaching and learning, engagement, development and needs of learners, policy, history, ... →

Content to the program

Research on teachers and teacher education

- Professional/effective teacher,
- Structure and origins of teacher knowledge,
- Teacher identity, agency, ...
- University pedagogy. →

Type of pedagogy and activities

Collaborative design of the Programme

International and National strategies

- Teacher education strategy,
- National level curriculum;
- OECD, EU, UNESCO strategies and models

Feedback

- Students' learning outcomes and course evaluations,
- Staff members' self-evaluations of the programme,
- Municipality stakeholders' feedback.