Bildung in Science Education

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Jesper Sjöström, Professor of Science Education
DASERA-seminar in Vejle 2021-11-18

1

Instrumentalism vs. Relationalism

- Much of contemporary education:
- Focus on learning and assessable learning results
- Mainly reading and writing skills and disciplinary facts
- INSTRUMENTALISM

Competence

- An alternative view:
- Focus on teaching, contextual knowledge and (philosophical) values.
- Development of powerful knowings and eco-reflexivity
- RELATIONALISM

Bildung

Based on: Jesper Sjöström, Invited Keynote-presentation at the Korean Association for Science Education (KASE) International Conference at Dankook University, South Korea, January 25-27, 2018.

Willbergh, I. (2015). The problems of 'competence' and alternatives from the Scandinavian perspective of *Bildung*. *Journal of Curriculum Studies*, *47*(3), 334-354.

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2

The competence discourse

"The competence discourse has been subject to criticisms. **Competence is an economical rather than an educational concept**, which finds its origin in the field of human resources management." (p. 2)

Deng, Z. (2021). Powerful knowledge, transformations and Didaktik/curriculum thinking. *British Educational Research Journal,* ahead-of-print

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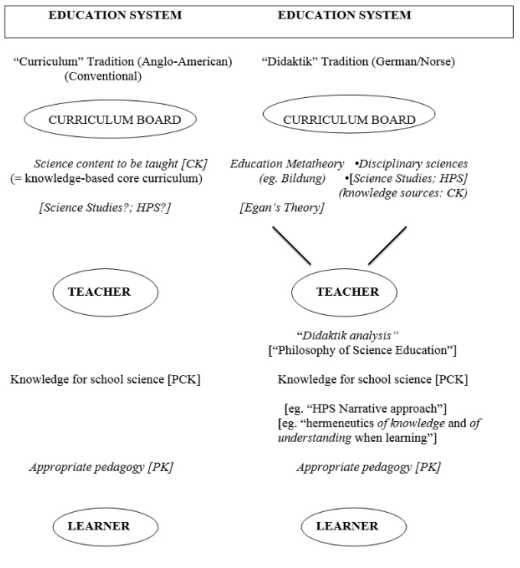
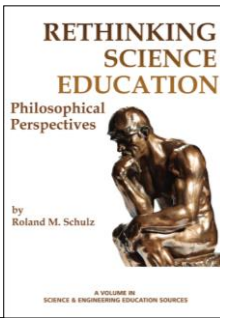


Source: Revised from Fensham (2004, p. 149, Fig. 10.1, with reference to Shulman, 1987).

Figure 3.1. Two curriculum traditions.

Schulz, R. M, (2014). *Rethinking science education: Philosophical perspectives*. Charlotte: Information Age Publishing.

(2014)



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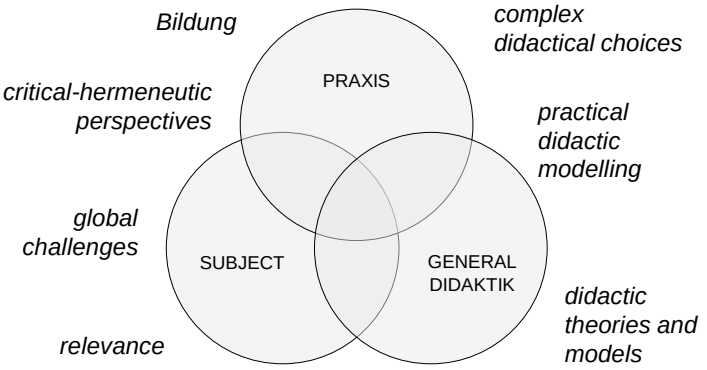
Central concepts of general subject didactics for sustainability



Translated from: Sjöström, J. (2018). Didaktik i integrativa lärarprofessionsämnen, *Studier i læreruddannelse og –profession*, *3*(1), 94-119.

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The concept of *Bildung*

- **(Trans)formation** of the whole person
- A lifelong (inwardly controlled) process that affects one's philosophy of life and worldview
- Early thoughts about **wisdom** in e.g. Egypt, Babylon, India and China
- Historical link to ancient Greek **paideia**, which was a "fully developed theory of *Bildung*", although the term was not used.
- Meister Eckhart (1260-1328) coined the term ***Bildung*** already in the 13th century. In the first five hundred years the concept had theological and spiritual connotations.
- Late 18th century Germany: A **modern *Bildung*-concept**, based on ideas from e.g. ancient Greece, contemporary England and France, but also from a Christian (especially pietistic) tradition. It was related to educational thinking.
- The concept spread to other German speaking countries, Scandinavia and Russia, but not to England, France and Spain.

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Five historical elements in conceptualisations of *Bildung*

- Connection to ancient cultures – **paideia**
- Biological-organic growth process (self-learning is a prerequisite for **humanism**)
- Religious elements (transparency for a **spiritual world** in contrast to only materialism)
- Enlightenment thoughts (forming informed **democratic citizens**)
- Socio-political dimension (**emancipation**)

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability, *Science & Education, 29*(1), 145-185.

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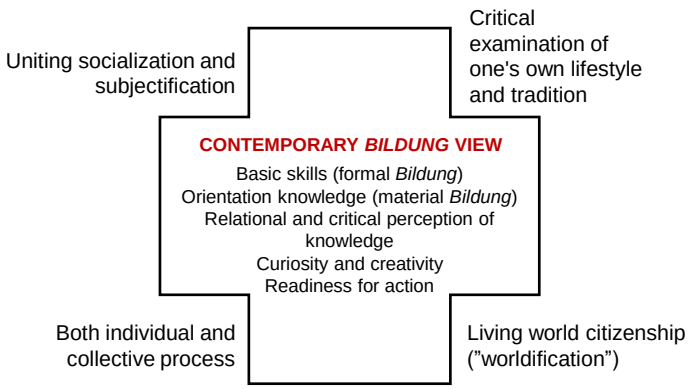

Translated from figure in: Sjöström, J. & Tyson, R. (to be published 2022). *Didaktik för lärande och bildning – att undervisa för förståelse, kreativitet, kunnande och etiskt orienterat handlande*, Stockholm: Liber.

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Wolfgang Klafki (1927-2016): *Bildung &* Didaktik

- Formal *Bildung* and Material *Bildung*

		Content orientation	
		Low	**High**
Skills orientation	**Low**		Material *Bildung*
	High	Formal *Bildung*	Categorical *Bildung*

Fig. 5.1 Relationships between material, formal, and categorical *Bildung*

- **Categorical *Bildung*** as a ”double unlocking”; both the knowledge and the student should be unlocked
- *Allgemeinbildung* for emancipation and solidarity
  - Self-determination
  - Co-determination
  - Solidarity
- **Critical-Constructive Didaktik** focusing on teaching and learning relevant subject knowledge

Sjöström, J., & Eilks, I. (2020). The *Bildung* theory – from von Humboldt to Klafki and beyond. Chapter 5 in B. Akpan & T. J. Kennedy (Eds.), *Science Education in Theory and Practice* (pp. 55-67). Springer Texts in Education. Cham: Springer.

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Klafki’s Didaktik analysis

1. What wider or general sense or reality does this content exemplify and open up to the learner? What basic phenomenon or fundamental principal, law, criterion, problem, method, technique or attitude can be grasped by dealing with **this content as an ”example”**?
2. What **significance** does the content in question, or the experience, knowledge, ability, or skill to be acquired through this topic already process in the minds of the children in my class? What significance should it have from a pedagogical point of view?
3. What constitutes the topic’s significance for the **children’s future**?
4. How is the **content structured** which has been placed in a specifically pedagogical perspective by questions I, II and III?
5. What are the special cases, phenomena, situations, experiments, persons, elements of **aesthetic experience**, and so forth, in terms of which the structure of the content in question can become interesting, stimulating, approachable, conceivable, or vivid for children of the stage of development of this class?

Sjöström, J., & Eilks, I. (2020). The *Bildung* theory – from von Humboldt to Klafki and beyond. Chapter 5 in B. Akpan & T. J. Kennedy (Eds.), *Science Education in Theory and Practice* (pp. 55-67). Springer Texts in Education. Cham: Springer.

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Responsible relationships

- *Bildung* is about "the individual **embedded in a world**" (Løvlie & Standish, 2002, p. 319)

Løvlie, L., & Standish, P. (2002). Introduction: *Bildung* and the idea of a liberal education. *Journal of Philosophy of Education*, *36*, 317-340.

- "To capture a conception of human subjectivity that is not selfish or self-centered, but always understood as being in **responsible relation** with other human beings and, by extension, **with the natural world** more generally"

Biesta, G. (2013). Responsive or responsible? Democratic education for the global networked society. *Policy Futures in Education*, *11*, 733-744.

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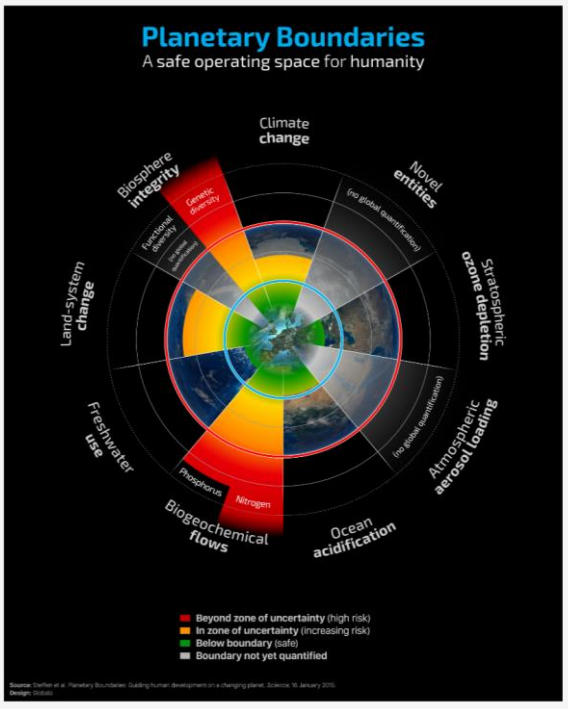
Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, I. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 736-747.



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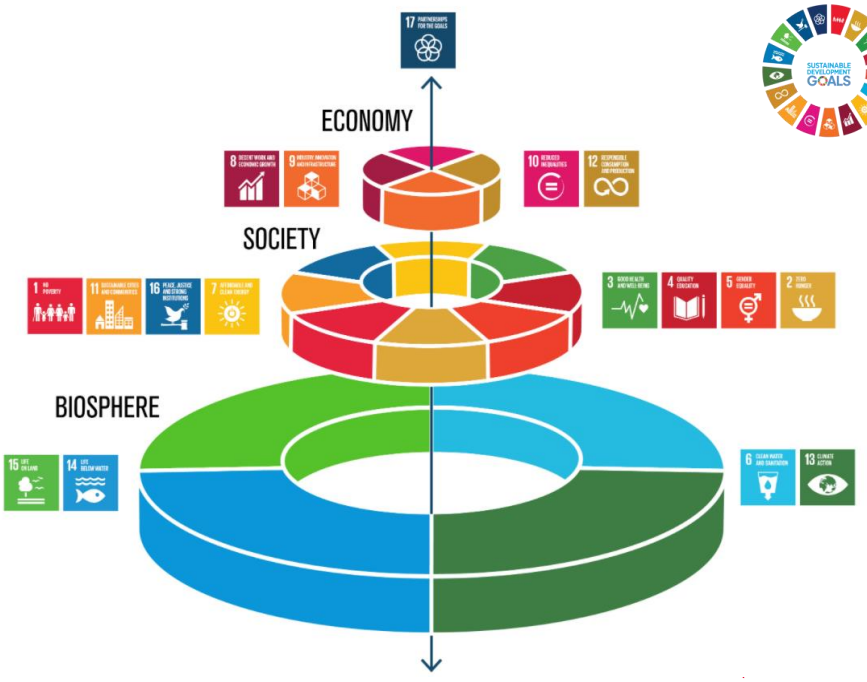

Azote Images for Stockholm Resilience Centre, Stockholm University

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Bildung and Didaktik

”*Bildung* as an Essential Element of Didaktik”

Fischler, H. (2011). Didaktik—An Appropriate Framework for the Professional Work of Science Teachers? In *The professional knowledge base of science teaching* (pp. 31-50). Springer Netherlands, p. 33

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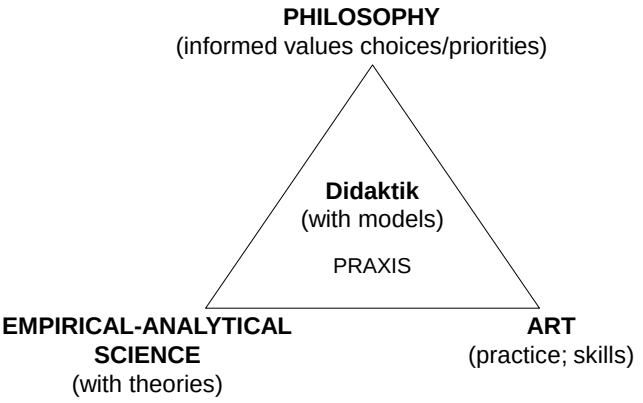
Didaktik – teachers' science, art and philosophy



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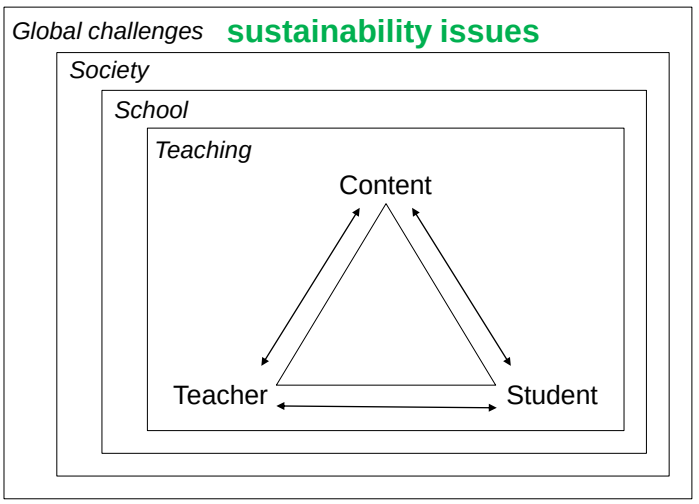
Extended Didaktik triangle

WHY? Philosophical Ideas **WHAT?** Choices of Context and Content



HOW? Pedagogy and Methods

Sjöström, J. (2019). Didactic modelling for socio-ecojustice. *Journal for Activist Science and Technology Education*. *10*(1), 45-56.

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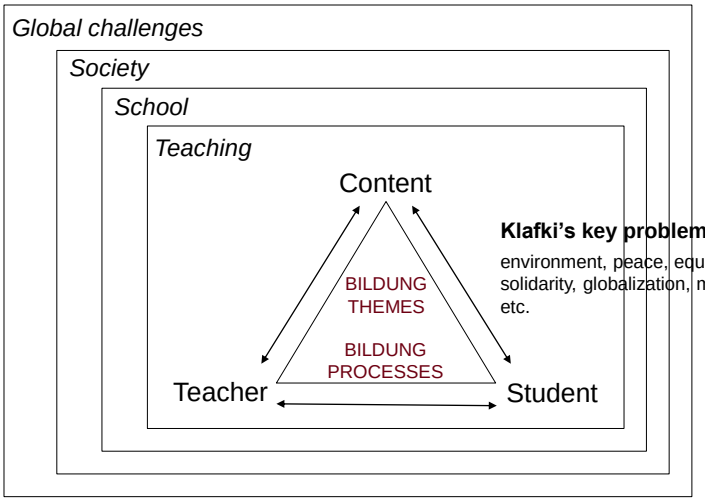
VISIONS ABOUT BILDUNG

Ideas about the human subjects and the world
epistemology, view of humans, societal view, worldview

WHY? Philosophical Ideas **WHAT?** Choices of Context and Content



Klafki's key problems
environment, peace, equality, solidarity, globalization, migration etc.

HOW? Pedagogy and Methods

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Connection to Science Education?

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Science as part of Bildung for all – a critical subject-Didaktik

- Four arguments for science for all
  - –Economy
  - –Usefulness
  - –Democracy
  - –Culture

(3:d ed., 2010)

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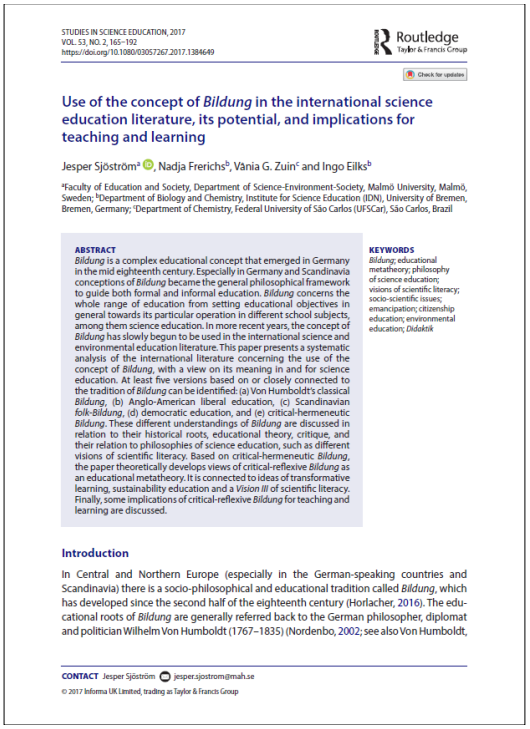

STUDIES IN SCIENCE EDUCATION, 2017
VOL. 53, NO. 2, 165–192
https://doi.org/10.1080/03057267.2017.1384649

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Use of the concept of *Bildung* in the international science education literature, its potential, and implications for teaching and learning

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ABSTRACT

Bildung is a complex educational concept that emerged in Germany in the mid eighteenth century. Especially in Germany and Scandinavia conceptions of *Bildung* became the general philosophical framework to guide both formal and informal education. *Bildung* concerns the whole range of education from setting educational objectives in general towards its particular operation in different school subjects, among them science education. In more recent years, the concept of *Bildung* has slowly begun to be used in the international science and environmental education literature. This paper presents a systematic analysis of the international literature concerning the use of the concept of *Bildung*, with a view on its meaning in and for science education. At least five versions based on or closely connected to the tradition of *Bildung* can be identified: (a) Von Humboldt's classical *Bildung*, (b) Anglo-American liberal education, (c) Scandinavian *folk-Bildung*, (d) democratic education, and (e) critical-hermeneutic *Bildung*. These different understandings of *Bildung* are discussed in relation to their historical roots, educational theory, critique, and their relation to philosophies of science education, such as different visions of scientific literacy. Based on critical-hermeneutic *Bildung*, the paper theoretically develops views of critical-reflexive *Bildung* as an educational metatheory. It is connected to ideas of transformative learning, sustainability education and a *Vision III* of scientific literacy. Finally, some implications of critical-reflexive *Bildung* for teaching and learning are discussed.

KEYWORDS

Bildung; educational metatheory; philosophy of science education; visions of scientific literacy; socio-scientific issues; emancipation; citizenship education; environmental education; *Didaktik*

Introduction

In Central and Northern Europe (especially in the German-speaking countries and Scandinavia) there is a socio-philosophical and educational tradition called *Bildung*, which has developed since the second half of the eighteenth century (Horlacher, 2016). The educational roots of *Bildung* are generally referred back to the German philosopher, diplomat and politician Wilhelm Von Humboldt (1767–1835) (Nordenbo, 2002; see also Von Humboldt,

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Autumn 2016 Autumn 2021

Table 1. Hits for 'Bildung' searched in connection to 'science education' and biology, chemistry and physics education as well as 'environmental education', respectively.

Bildung connected to	Web of knowledge	ERIC	Google scholar		
Science education	35	8	6200	14100	+127%
Biology education	3	0	240	649	+170%
Chemistry education	4	1	397	937	+136%
Physics education	1	0	557	1010	+81%
Environmental education	3	8	2060	4070	+98%

Sjöström, J., Frerichs, N., Zuin, V. G., & Eilks, I. (2017). Use of the concept of *Bildung* in the international science education literature, its potential, and implications for teaching and learning. *Studies in Science Education*, *53*(2), 165-192.

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Humanised Science Education

oriented approach. Also Aikenhead (2006) subsumes the term 'Bildung' under the general idea of 'humanistic school science worldwide' (p. 21), together with such concepts as science, technology, society and environment (STSE), science for public understanding, science-technology-citizenship, citizen science, functional scientific literacy, PUS, SSI, or cross-curricular school science. In general, *Bildung*-oriented science education is an example of humanised science education (Schulz, 2009).

& Eilks, in press; Ståhl & Hussénius, 2017; Stuckey et al., 2013; Zuin, 2012). All the analysed publications clearly state that *Bildung* in relation to science education is connected to, but not identical to, 'scientific literacy'. Although some newer versions of scientific literacy encompass e.g. science for critical citizenship (e.g. Albe, 2015), complex versions of SSI-based science education (e.g. Zeidler, 2015), and STSE education (e.g. Pedretti & Nazir, 2015), the earlier

Nowadays the concept of *Bildung*, in addition to connotations related to its historical roots in both Romanticism and Enlightenment, stands for critical-democratic awareness and agency.

Sjöström, J., Frerichs, N., Zuin, V. G., & Eilks, I. (2017). Use of the concept of *Bildung* in the international science education literature, its potential, and implications for teaching and learning. *Studies in Science Education*, *53*(2), 165-192, p. 176-177.

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Critical scientific literacy

- = critical scientific, technological and environmental literacy (Hodson 2011)
- The aim of critical scientific literacy is to have knowledge and abilities for being an autonomous, responsible-taking and action-competent citizen, working in the interest of socio-ecojustice and global sustainability

Hodson, D. (2011). *Looking to the future – building a curriculum for social activism*. Rotterdam: Sense Publishers.

- Learning science and technology (e.g. conceptual understanding) content
- Doing science and technology (e.g. scientific inquiry) NOS
- Learning *about* science and technology STSE
- Engaging in socio-political action action competence

Hodson, D. (2009). *Teaching and learning about science: Language, theories, methods, history, traditions and values*. Rotterdam: Sense.

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Scientific literacy in the 21st century

- Content knowledge
- Habits of mind
- Character and values
- Science as human endeavor
- Metacognition and self-direction

Mun, K., Shin, N., Lee, H., Kim, S.-W., Choi, K., Choi, S.-Y., & Krajcik, J. S. (2015). Korean secondary students' perception of scientific literacy as global citizen: using global scientific literacy questionnaire. *International Journal of Science Education*, *37*, 1739-1766.

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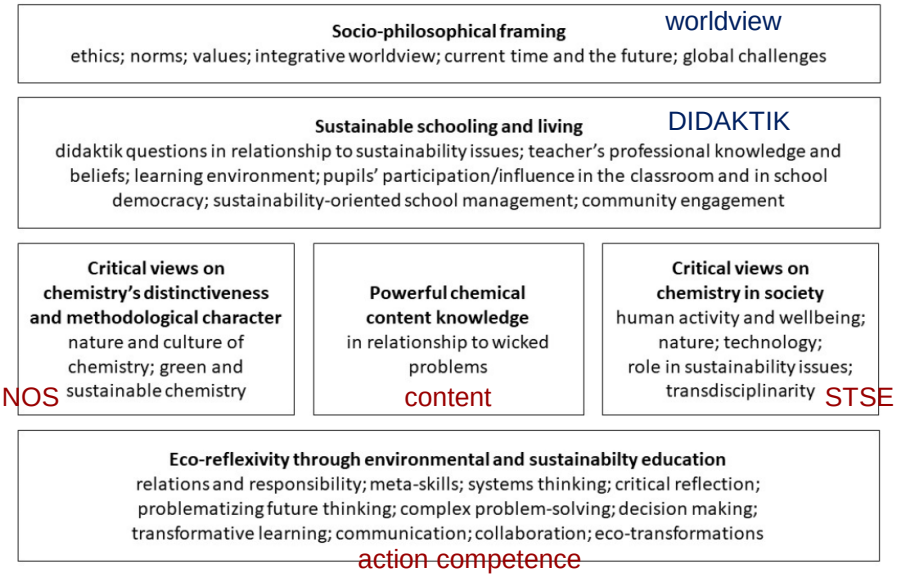

Figure 3. Didaktik model for eco-reflexive chemistry education.

Herranen, J., Yavuzkaya, M., & Sjöström, J. (2021). Embedding chemistry education into Environmental and Sustainability Education: Development of a didaktik model based on an eco-reflexive approach, *Sustainability*, *13*, article 1746.

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Five *Bildung* versions/traditions

- Classical *Bildung* (von Humbolt)
- Scandinavian 'folk-*Bildung'*
- Anglo-American liberal education
- Dewey's democratic education
- Critical-reflexive *Bildung* (Klafki)

Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of Bildung. In: Y. Dori, Z. Mevarech, D. Baker (eds.), *Cognition, Metacognition, and Culture in STEM Education – Learning, Teaching and Assessment* (pp. 65-88). Cham: Springer.

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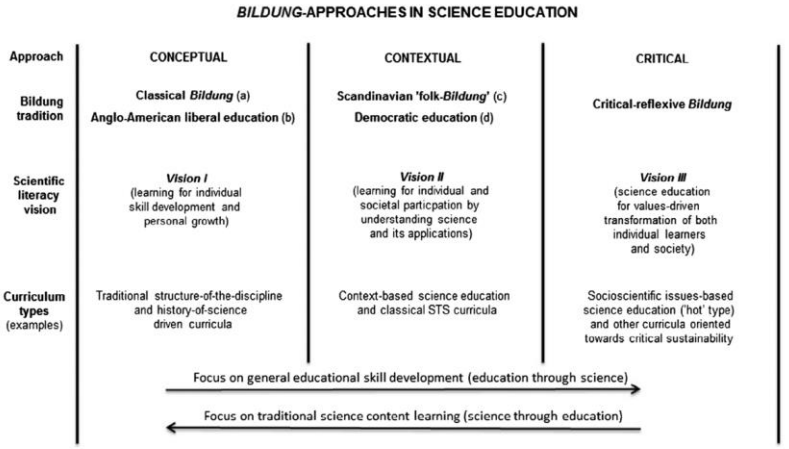

Figure 1. Different versions of *Bildung*-based science education.

Sjöström, J., Frerichs, N., Zuin, V. G., & Eilks, I. (2017). Use of the concept of Bildung in the international science education literature, its potential, and implications for teaching and learning. *Studies in Science Education*, 53(2), 165-192.

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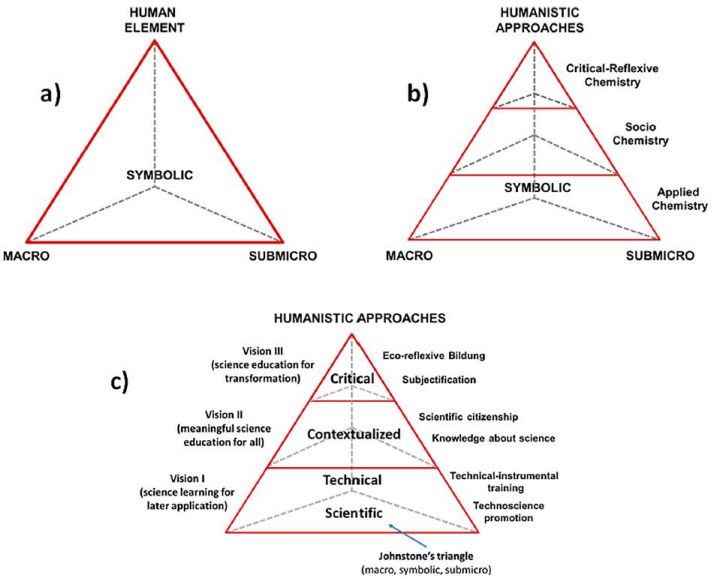

Figure 2. (a) Mahaffy's tetrahedron[31] and (b) the tetrahedron structured by adding a relevance dimension.[13,32] (c) Different levels in the relevance dimension point to different visions of scientific literacy and science education.[33]

Sjöström, J., Eilks, I., & Talanquer, V. (2020). Didaktik models in chemistry education. *Journal of Chemical Education*, *97*(4), 910−915.

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Philosophy of eco-reflexive (science) education

- Problematisation of the "modern" society
  - Risk society, globalization, oppressive context, neoliberalism, anthropocentrism
- Value orientation/worldview
  - Life and society are interdependent, an inseparable whole
- Educational ideal
  - *Bildung* and emancipation: critical-reflexive, sustainability-problematizing and action-competent subjects/citizens
  - Emphasis on holistic thinking (whole complex systems; transdisciplinarity; uncertainty)
  - Contextualization and politicization
- ……

Sjöström, J., Eilks, I., & Zuin, V. (2016). Towards eco-reflexive science education. *Science & Education*, *25*, 321-341.

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Philosophy of eco-reflexive science education

- Problematisation of "modern" science (education):
  - Discourse/ideology analysis shows: objectivism, reductionism, mechanistic, value-free, rationalism, modernism, scientific imperialism
- Eco-reflexive science / chemistry education
  - Complex SSIs which carry both uncertainties and risks and are controversial
  - Emphasis on ethical and political values
  - Skepticism: Scientific reflexivity is necessary
  - Knowledge *about* STSE (meta-perspectives)
  - Nature of Science (NOS)-aspects
  - Conceptual tools (e.g. energy and matter flows, process/product, macro/submicro)
  - Multidimensional teaching, including authentic activities and values pluralism
  - Learning that involves the head, heart and hands

Sjöström, J., Eilks, I., & Zuin, V. (2016). Towards eco-reflexive science education. *Science & Education*, *25*, 321-341.

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Knowledge in and about chemistry

Facets of Chemistry Knowledge	Level 0 – Pure Chemistry	Level 1- Applied Chemistry	Level 2- Socio Chemistry		Level 3- Critical-Reflexive Chemistry	
			a) Socio-historical	b) Socio-scientific	a) Socio-cultural	b) Socio-political
Essential Questions	Focus on core disciplinary queries: *What types of matter are there?*	Focus on questions of public interest: *How can we design new drugs?*	Focus on questions about the nature of knowledge: *How have ideas about atomic structure evolved?*	Focus on questions of relevance to individuals and modern societies: *Which type of fat should we eat?*	Include questions about knowledge development and application: *What factors influence the choice of fossil fuels over other sources?*	Include value-centered questions of relevance to a sustainable society: *Should perfluorinated chemicals be allowed on Earth?*
Big Ideas	Include fundamental ideas in the discipline: *Matter is atomic*	Include ideas of relevance in modern times: *Combustion engines produce greenhouse gases*	See Level 0	Include ideas that integrate STSE issues: *Green chemistry seeks to use less energy and produce less waste*	Include ideas of understanding and problematizing science and technology systems in socio-cultural context: *Between the public and the scientific communities there are often differences in values, perspectives on problems, and preferred solutions*	Include ideas that problematize STSE issues aiming at transformation for critical citizenship and socio-ecojustise: *The chemical industry has generated more benefits and fears than any other sector*
Crosscutting Concepts	Refer to central disciplinary concepts: *Chemical bonding*	Refer to current societal concerns: *Pollution*	See Level 0	Refer to central STSE issues: *Sustainable development*	Refer to and problematizes central STSE issues: *Sustainability*	See Level 3a
Conceptual Dimensions	Commonly focused on the composition/structure dimension	Tend to focus on composition/structure and energy dimensions	See Level 0	Seek to integrate composition/structure, energy, and time dimensions	See Level 2b	See Level 2b
Knowledge Types	Frequently emphasizing interpretation and manipulation of visualizations (symbolic representations)	Emphasis on connecting experiences and models using appropriate visualizations	See Level 1	See Level 1	See Level 1	See Level 1
Dimensional Scales	Commonly focused on *submicroscopic* descriptions	Focused on building connections between *macroscopic* and *submicroscopic* descriptions	See Level 1	Focused on building connections between descriptions at various dimensional scales	See Level 2b	See Level 2b
Modes of Reasoning	Frequently emphasizing *rule-based* and *case-based* reasoning	Emphasis on *case-based* and *model-based* reasoning	Emphasis on modes of reasoning appropriate for particular goals and contexts	See Level 2a	See Level 2a	See Level 2a
Contextual Issues	If addressed, only as isolated scenarios for numerical problems	Addressed in an isolated manner or to serve as a guide in organizing the presentation of fundamental chemistry content	Socio-cultural embeddedness of scientific ideas and individual scientists' work	Contextual issues used to organize the curriculum	Socio-cultural embeddedness of science and technology	Critical-democratic issues used to engage students in decision making and practical activity in both local and global contexts
Historical Views	Not addressed	Marginally addressed as anecdotes and isolated vignettes	Consideration of historical developments of relevance to the issues at hand	See Level 2a	Consideration of historical contexts	Consideration of historical contexts in judgment and decision-making
Philosophical Considerations	Not addressed	Not addressed	Nature of knowledge aspects are considered, including problematization of chemical concepts, laws and models	Recognition of ethical and moral dilemmas	Philosophical considerations about the nature of chemistry knowledge are taken into account	Philosophical considerations include integration of ethical and moral concerns in judgment, decision-making and actions

Sjöström, J., & Talanquer, V. (2014). Humanizing chemistry education: from simple contextualization to multifaceted problematization. *Journal of Chemical Education*, *91*(8), 1125-1131.

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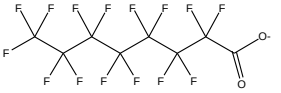
b) Socio-political

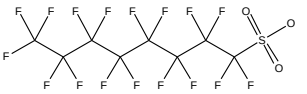
Include value-centered questions of relevance to a sustainable society:
Should perfluorinated chemicals be allowed on Earth?

Include ideas that problematize STSE issues aiming at transformation for critical citizenship and socio-ecojustise:
The chemical industry has generated more benefits and fears than any other sector

Should perfluorinated chemicals be allowed on Earth?



Perfluorooctanoate (PFOA)



Perfluorooctane sulfonate (PFOS)

Sjöström, J., & Talanquer, V. (2014). Humanizing chemistry education: from simple contextualization to multifaceted problematization. *Journal of Chemical Education*, *91*(8), 1125-1131.

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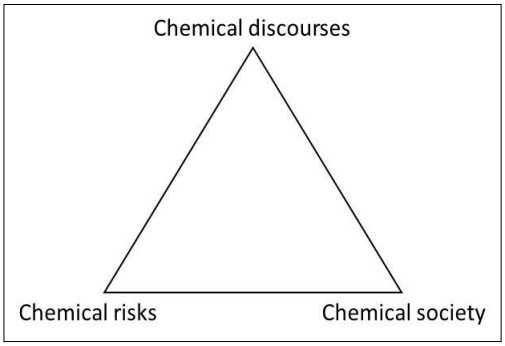
Didaktik model about risk chemicals

- Nature of chemical risks
- Interplay between actors in “the chemical society”
- Pluralism and awareness regarding various “chemical discourses”



Sjöström, J., & Stenborg, E. (2014). Teaching and learning for critical scientific literacy: communicating knowledge uncertainties, actors interplay and various discourses about chemicals. In I. Eilks, S. Markic & B. Ralle (eds.) *Science Education Research and Education for Sustainable Development* (pp. 37-48), Aachen: Shaker Verlag.

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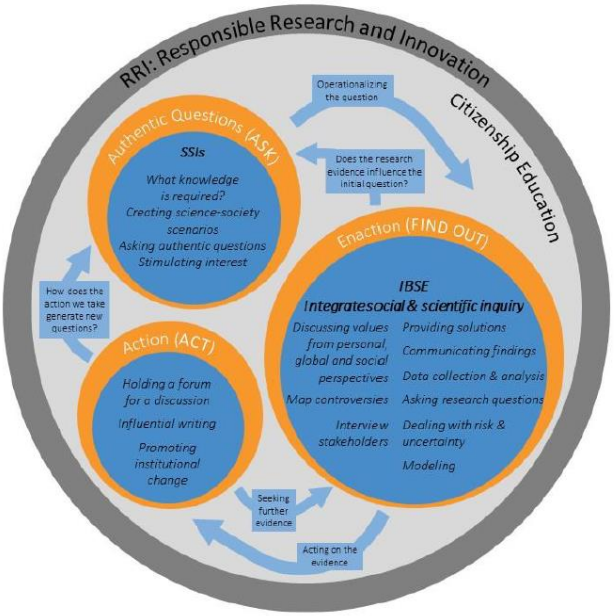

Ariza, M. R., Christodoulou, A., Harskamp, M. V., Knippels, M. C. P., Kyza, E. A., Levinson, R., & Agesilaou, A. (2021). Socio-Scientific Inquiry-Based Learning as a Means toward Environmental Citizenship. *Sustainability*, *13*(20), 11509.

Figure 1. Socio-Scientific Inquiry-Based Learning. Figure based on [19] (p.15–16), adapted by Knippels and van Harskamp.

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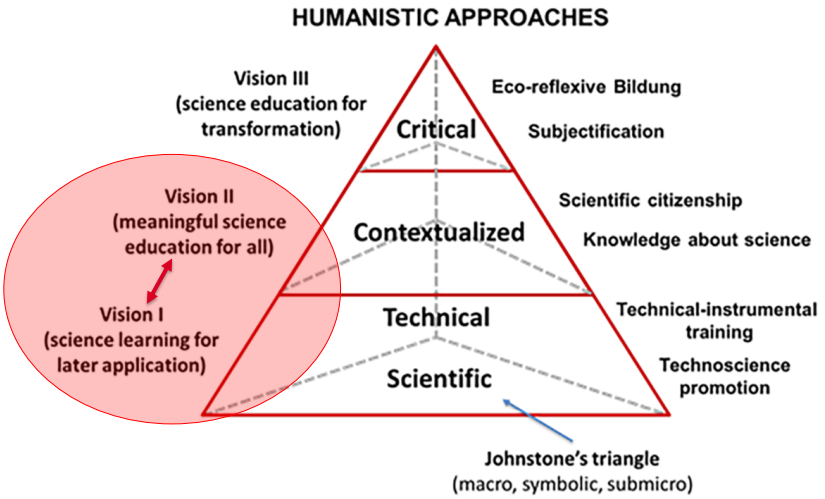

Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of *Bildung*. In: Y. Dori, Z. Mevarech, D. Baker (eds.), *Cognition, Metacognition, and Culture in STEM Education – Learning, Teaching and Assessment* (pp. 65-88). Cham: Springer.

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Roberts' Curriculum Emphases in Science Education

- Solid Foundation
- Correct Explanations
- Self as Explainer
- Everyday Coping
- Science, Technology, and Decisions
- Scientific Skill Development
- Structure of Science

Vision II

Roberts, D. A. (1982). Developing the concept of "curriculum emphases" in science education. *Science Education*, *66*, 243-260.

Roberts, D. A. (2007). Scientific Literacy / Science Literacy. In S. K. Abell & N. G. Lederman (eds.), *Handbook of research on science education* (pp. 729-780). Mahwah: Lawrence Erlbaum.

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Educational philosophical orientations

- **Vision I:** *essentialism*; rationalist-objectivist focus; scientism; hierarchical configuration
- **Vision II:** *progressivism*; Western modernism; anthropocentrism; body-mind dualism; utilitarianism; liberal education-perspectives; professional configuration
- **Vision III:** *reconstructionism*; late/post-modern perspectives; embodied science; relationalism; biocentrism; problematizing/critical configurations

Sjöström, J. (2018). Science teacher identity and eco-transformation of science education: comparing Western modernism with Confucianism and reflexive *Bildung*. *Cultural Studies of Science Education*, *13*(1), 147-161.

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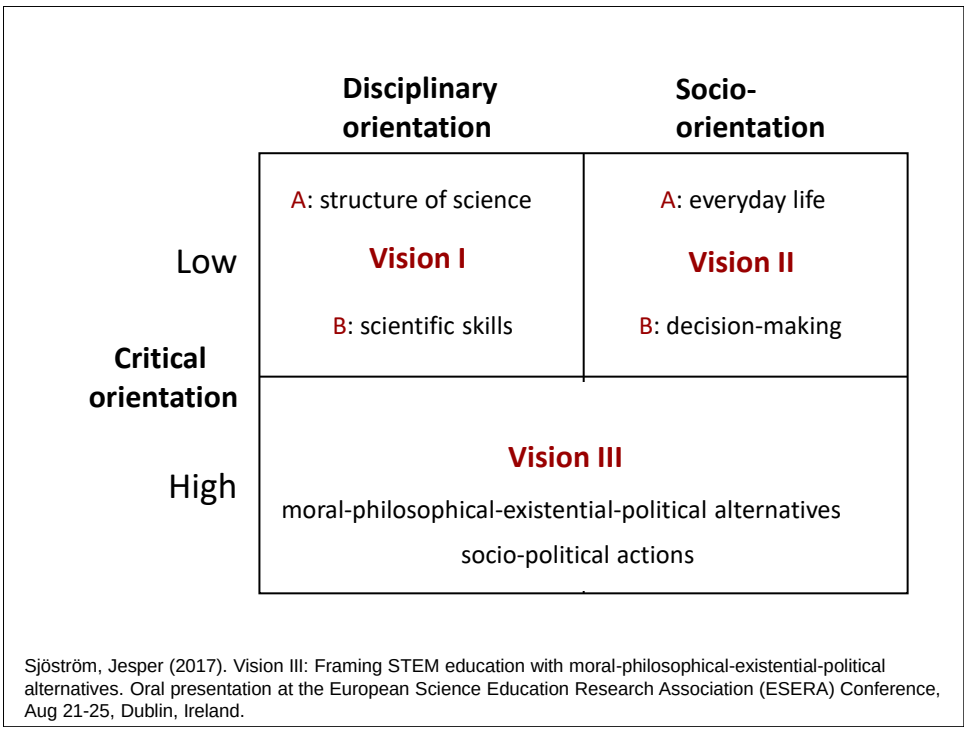

Sjöström, Jesper (2017). Vision III: Framing STEM education with moral-philosophical-existential-political alternatives. Oral presentation at the European Science Education Research Association (ESERA) Conference, Aug 21-25, Dublin, Ireland.

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Three educational scenarios for the future

- **Future 1** — *Content focused.* Boundaries are given and fixed — the 'Future' is associated with a naturalised or *'undersocialised'* concept of knowledge
- **Future 2** — *Skills focused.* The end of boundaries — the 'Future' is associated with an *'oversocialised'* concept of knowledge
- **Future 3** — Boundary maintenance as prior to boundary crossing. In this 'Future' it is the variable relation between the two that is the condition for the creation and acquisition of new knowledge. **Powerful Knowledge** refers to discipline-grounded knowledge important for all. *Based on a social realist theory of knowledge.*

Young, M., & Muller, J. (2010). Three educational scenarios for the future: lessons from the sociology of knowledge. *European Journal of Education*, *45*(1), 11-27.

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Powerful Knowledge

- "Powerful knowledge opens doors: it must be available to all children"
- "Children need powerful knowledge to understand and interpret the world."
- "It transcends and liberates children from their daily experience."
- "We teach what they need to make sense of and improve the world"

Young, M. (2013). Overcoming the crisis in curriculum theory: a knowledge-based approach. *Journal of Curriculum Studies*, *45*(2), 101-118, p. 117-118.

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Powerful Knowings and *Bildung*

Carlgren (2020) has problematized powerful knowledge (powerful knowns) and instead suggested *powerful knowings*. This latter concept emphasizes that disciplinary knowledge is embedded in actions. It is about "knowledge-as-a-means-for-cultivation-of-human-powers" (p. 324). It has similarities with Klafki´s categorical *Bildung*.

Similarly, Deng (2020) has emphasized cultivation of human powers via knowledge (capabilities, way of thinking, understanding worlds)

Carlgren, I. (2020). Powerful knowns and powerful knowings. *Journal of Curriculum Studies*, *52*, 323-336.

Deng, Z. (2020). *Knowledge, content, curriculum and didaktik: Beyond social realism*. Routledge.

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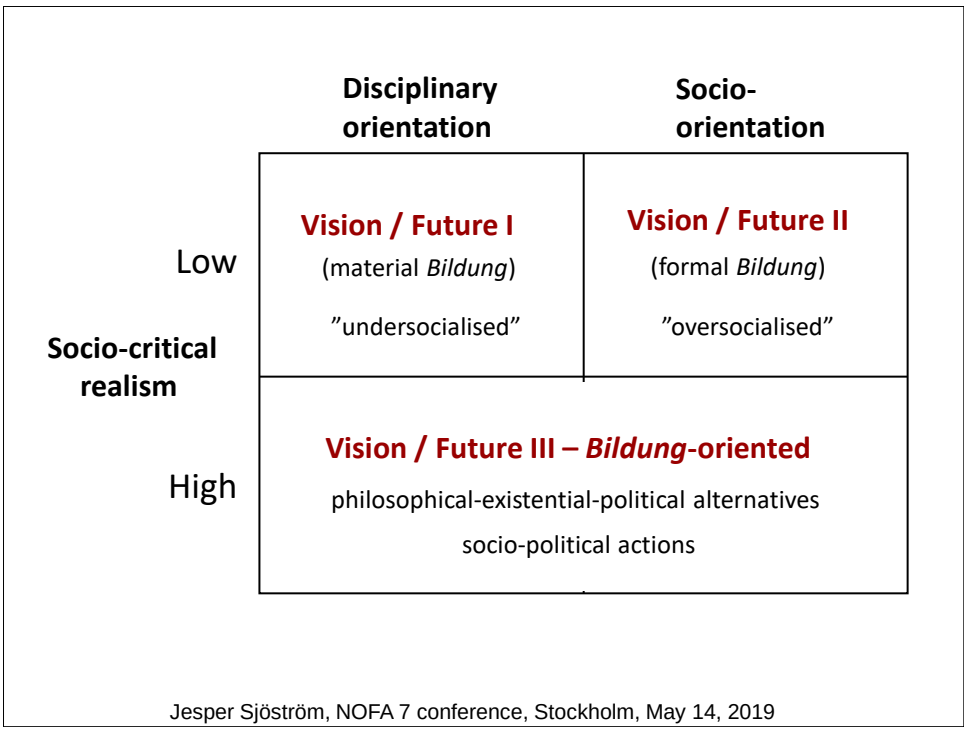

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A model for eco-reflexive *Didaktik*

Philosophical ideas	Objectives (WHY?)	Criteria for selecting issues and approaches (WHAT?)	Teaching methods (HOW?)	Structure of lessons and projects
Holism and Ecocentrism	Reflexive *Bildung* and Transformative learning	Sustainability issues	Integrating cognitive and affective domains (incl. dialogic processes)	1. Problem analysis
Critical realism	Problematization, Emancipation, Subjectification, Praxis	Relevant, controversial and complex socio-scientific issues	Inquiry-based learning (incl. practical work)	2. Clarifying the science background and context
Egalitarianism and Altruism	Vision III of scientific literacy	Authenticity	Relevant media (incl. authentic)	3. Resuming the socio-political-scientific controversy
Humanization (plural knowledge and mutifacetted problematization)	Learning *in* and *about* science (incl. NOS and STSE)	Includes scientific knowledge and processes (incl. uncertainty)	Methods structuring scientific reasoning and controversial debating	4. Alternatives and examples of actions for socio-ecojustice
Reconstructionism and Critical pedagogy	Promotion of critical and responsible citizenship	Allows for open discussion (incl. different discourses)	Methods provoking the explication of individual opinions and actions	5. Meta-reflection (incl. analysis of knowledge emphases and possible activism)

Sjöström, J. (2019). Didactic modelling for socio-ecojustice. *Journal for Activist Science and Technology Education*. *10*(1), 45-56.

Original model in: Marks, R. & Eilks, I. (2009). Promoting scientific literacy using a socio-critical and problem-oriented approach to chemistry teaching: concept, examples, experiences. *International Journal of Environmental and Science Education*, *4*, 131-145.

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Didaktik models

Didaktik models may look different, but have in common that they support teachers when reflecting on, answering and/or are practicing teaching based on the didactic questions: why, what, and how to teach a certain content for a certain group of learning subjects. Didaktik models are useful in both planning and evaluation of teaching as well as in-action, and constitute the basis for teachers' professional judgment and reflection.

Sjöström, Jesper & Vallberg Roth, Ann-Christine (2021), Didaktik models as a bridge between theories and teaching practice. *Teachers Matter – but How?; an international conference on Didaktik, pedagogy, and classroom research*, October 13-15, 2021, Linnaeus University, Växjö, Sweden.

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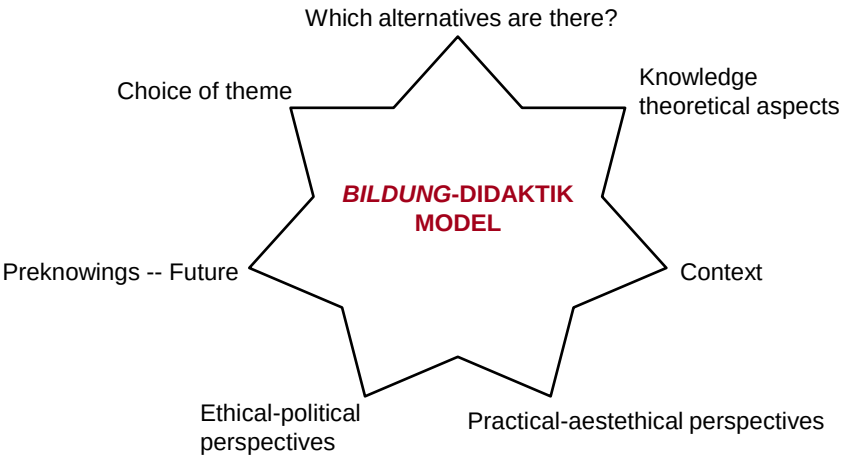

Translated from figure in: Sjöström, J. & Tyson, R. (to be published 2022). *Didaktik för lärande och bildning – att undervisa för förståelse, kreativitet, kunnande och etiskt orienterat handlande*, Stockholm: Liber.

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Emphasizing alternatives

"Pedagogy worthy of the designation 'critical' must not only initiate into particular ethical viewpoints but also offer exposure to alternative perspectives."

Alexander, H. A. (2018). What is critical about critical pedagogy? Conflicting conceptions of criticism in the curriculum. *Educational Philosophy and Theory*, *50*(10), 903-916.

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21st century competencies

- Citizens' key competences according to the EU :
  - Communication on the mother tongue
  - Communication in foreign languages
  - Mathematical knowledge and basic technical and scientific competence
  - Digital competence
  - Meta-learning
  - Social and civic skills
  - Initiative ability and entrepreneurship
  - Cultural awareness and ability for cultural expressions

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21st century competencies

- Citizens' key competences according to the EU :
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  - Digital competence
  - Meta-learning
  - Social and civic skills
  - Initiative ability and entrepreneurship
  - Cultural awareness and ability for cultural expressions

- At least this is missing
  - Knowledge in/about Nature of Science (NOS) and Science-Technology-Society-Environment interactions (STSE)
  - Historical, philosophical, social and political awareness
  - Human ecology awareness

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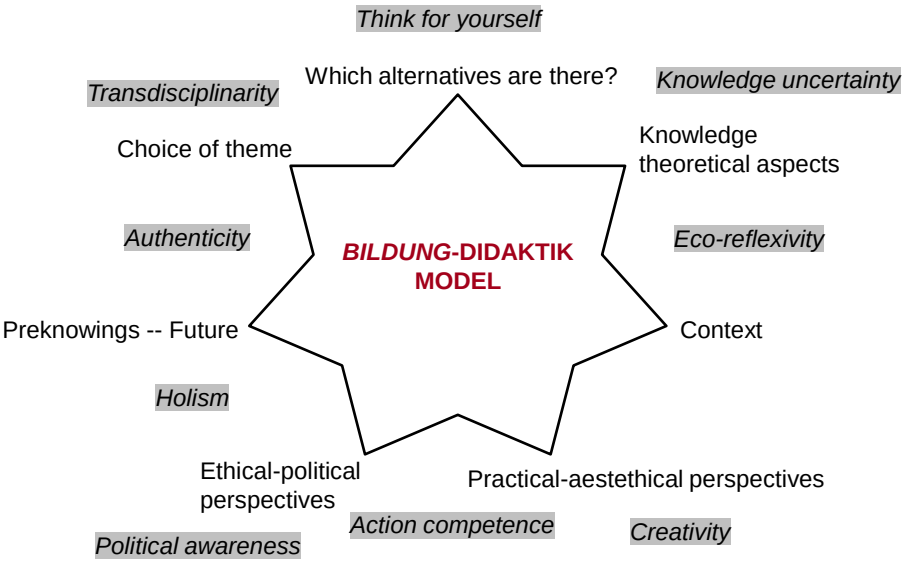

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