Generic competences in science teaching.

A challenge for practice and a topic for research.

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Generic Learning Goals

Policy-makers (in many parts of the world) increasingly call for science teaching to foster student learning and competence development related to:

- Inquiry
- Modelling
- Argumentation
- Technology
- Engineering
- Innovation
- Entrepreneurship
- Communication
- *Science Practices,*
- *21st century skills*

Learning goals that fall under these areas can be called **generic: they are targets of teaching in multiple disciplines or subjects,** and there is often no school discipline that they belong exclusively to.
Key definitions

A **generic learning goal** is a target of teaching in multiple disciplines or subjects, and does not exclusively belong to any one school discipline.

A **competence** is a readiness to act based on relevant knowledge and skills in a way that meets the challenges of a given situation (cf. Blomhøj & Jensen, 2003).
Example 1: Socioscientific Argumentation Competence

- Disciplinary knowledge/skills
- Societal issues
- Other relevant knowledge/skills

Paraphrased learning goal:
Students should be able to engage in argumentation and make informed decisions about societal issues by drawing on relevant knowledge and skills.
Uni-disciplinary: Generic goal is woven into the disciplines

Chemistry
Geography
Biology
Physics

In Denmark (year 10-12), **SSI argumentation competence** is a goal of most (science) disciplines on par with core disciplinary skills/knowledge.
Example 2: Inquiry Competence

Paraphrased learning goal:
Students should be able to formulate questions, plan and carry out investigations, analyse data, and communicate and discuss results by drawing on relevant knowledge and skills.
Cross-disciplinary:
Generic goal is explicitly cross-disciplinary

In Denmark (year 7-9), inquiry competence is one of four overarching competence goals for all science disciplines – these goals complement disciplinary knowledge/skills
**Uni-disciplinary:**
Generic goal is woven into the disciplines

**Cross-disciplinary:**
Generic goal is explicitly cross-disciplinary
Activity 1: From your perspective as researchers, what do you think could challenge the inclusion of the two learning goals in the science disciplines in a curriculum?

It may help to talk about how a teacher could teach for these learning goals in your own discipline.

One in each group types in your ideas on www.menti.com use code 86 64 70

SSI argumentation: Students should be able to engage in argumentation and make informed decisions about societal issues by drawing on relevant knowledge and skills.

Inquiry: Students should be able to formulate questions, plan and carry out investigations, analyse data, and communicate and discuss results by drawing on relevant knowledge and skills.
Main thematic challenges in the research

**Conceptual unclarity**: It is unclear (even to researchers) what these goals actually mean.

**Primacy of content**: A focus on disciplinary content often eclipses a focus on these goals.

**Issues about assessment**: These goals may be difficult for teachers to assess (formatively and summatively).
Main thematic challenges in the research

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Many scholars have focused on whether students use science evidence in SSI argumentation; but it is beginning to emerge that **SSI argumentation should be treated as being much richer** (Nielsen, 2013b, 2017)

Students can use science as strategic rhetoric devices or to ‘win the argument’ (Nielsen, 2011; 2012).

**We lack an operational concept of SSI argumentation** that outlines what it means to balance facts and values in legitimate ways.
Research on SSI argumentation: Primacy of content

- SSIs are often implemented in a **superficial fashion** (e.g. Lazarowitz & Bloch, 2005).

- Teachers’ narratives often reflect a **content-centred understanding** of SSI – where SSIs merely play an instrumental role in motivating the disciplinary content (Tidemand & Nielsen, 2017).
Research on Inquiry: Conceptual unclarity

• While ‘inquiry’ has been one of the most central notions of science education for at least 20 years, inquiry is not close to being uniformly defined.

• A recent review identified no less than 19 distinct skills/sub-competences that are regularly associated with inquiry competence in multifarious combinations (Bernholt et al., 2013).

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<th>Column</th>
<th>Content</th>
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<td>General information</td>
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<td>diagnosing problems/ identifying questions</td>
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<td>creating mental representations</td>
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<td>finding structures or patterns</td>
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<td>debating with peers/ communication</td>
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<td>problem solving</td>
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(Bernholt et al, 2013)
Research on Inquiry: Primacy of content

• In inquiry-based teaching the teacher-role becomes **complex** and focus is on guiding students through processes (e.g. Crawford, 2000).

• The complexity can lead teachers to stick to a role of **covering content** when teaching inquiry (e.g. Nielsen, 2017).

Teacher roles in inquiry teaching, after Crawford (2000)
Main thematic challenges in the research

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Assessment

Student activity

Next step in learning

Judgement of level

Data

Formative

Summative

Report of level

Justification in terms of assessment criteria

(after Harlen, 2013)
Assessment: one of the most important factors in education

- **Washback effect:** Over time the goings-on in teaching will become more and more aligned with what is being measured at in summative assessment (Harlen, 2007).
Activity 2:
Choose one of the two learning goals. From your perspective as researchers, what are your ideas about how to **summatively assess** the chosen learning goal?

Discuss what you think the key assessment criteria are and then come up with ideas for **which kind of student activity** is best suited for assessing the learning goal.

One in each group types in your ideas on **www.menti.com**

**SSI:** code 26 14 39
**Inquiry:** code 76 88 51
(you can write more than one idea)

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**SSI argumentation:**
Students should be able to engage in argumentation and make informed decisions about societal issues by drawing on relevant knowledge and skills.

**Inquiry:**
Students should be able to formulate questions, plan and carry out investigations, analyse data, and communicate and discuss results by drawing on relevant knowledge and skills.
Research on SSI argumentation: Issues about assessment

• Many science teachers feel unable to handle and give feedback on students’ SSI discussions (Bryce & Gray, 2004)

• There is a general lack of effective assessment criteria for assessing SSI argumentation (Levinson & Turner, 2001);

• Examinations rarely test SSI argumentation validly (if at all) (Tidemand & Nielsen, 2017).

• Most assessment frameworks for SSI argumentation are constructed for assessing written arguments – and would not lead to valid assessment of dialogic argumentation (Nielsen, 2013b)
Research on SSI argumentation: Issues about assessment

Typical summative assessment activities are not ideal for this competence

Formative
- Next step in learning

Summative
- Report of level

Justification in terms of assessment criteria

Data
- Lack of guides for teacher-judgement

Judgement of level
- Lack of support for teachers to translate the competence to criteria

Student activity
Research on Inquiry: Issues about (summative) assessment

• Large body of research into summative assessment of inquiry competences using multiple-choice, constructed-response or open-ended items (Bernholt et al., 2013).

• But it can be argued that this type of activity offers only a reduced vision of students’ inquiry learning – primarily focusing on student understanding (e.g. Hume & Coll, 2010).

Section 3A: Assessment
From Offspring Phenotypes to Mode of Inheritance I
In dragons, a single gene with two possible alleles determines visual ability. Use what you know about pedigrees to help you figure out these other things about visual ability.

1.1 Do the alleles for visual ability show complete dominance or incomplete dominance?

1.2 Explain what it is about the pedigree that distinguishes between complete and incomplete dominance.

2.1 Is the allele for blindness dominant, recessive, or incompletely dominant to the sighted allele? (Hint: use the circled part of the pedigree.)

2.2 Explain what it is about the circled part of the pedigree that tells you the answer, and explain why the parents and offspring that were not circled do not tell you the answer.

(Hickey & Zuiker, 2012, p. 24)
Research on Inquiry: Issues about (summative) assessment

- It may be, that using **performance assessment** is the best way to secure valid summative assessment of inquiry competence (e.g. Barron & Darling-Hammond, 2008).

- But performance assessment is more complex and time-consuming – and **requires substantial support** for teachers (Bernholt et al., 2013).

Research on Inquiry: Issues about (formative) assessment

- We have knowledge about **good practices** for formative assessment for inquiry – e.g. using structured whole-class discussions as assessment conversations (Ruiz-Primo & Furtak, 2007).

- But even experienced teachers **need support** in translating inquiry competence into assessment criteria that suits their practice (Nielsen, Tidemand & Dolin, 2018).

- Knowledge of good practices are only **slowly being implemented** in national assessment systems (Nielsen, 2017).

Ruiz-Primo & Furtak’s (2007, figure 1, p. 61) ESRU model of structuring formative assessment in classroom conversations.
Research on Inquiry: Issues about assessment

Typical summative assessment activities are not ideal for this competence

Student activity

Justification in terms of assessment criteria

Formative
Next step in learning

Data

Judgement of level

Multifarious skills that need to be translated into criteria

Summative
Report of level

Teachers need substantial support, may increase in performance assessment
## Main thematic challenges in the research

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<td>We have knowledge of good formative assessment practice, but changing assessment practices requires support</td>
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Generic learning goals face challenges in practice

- Primacy of content
- Issues about assessment
- Conceptual confusion

Future research needs to investigate the direction of the relations in order to provide strategies for professional development solutions.
How to welcome a generic learning goal to the curriculum!

Combining ideas from two research projects on generic learning goals, may be a path to follow

“Upper secondary school rethought”
(innovation competence)

(Inquiry competence)
How to welcome a generic learning goal to the curriculum!

**Conceptual clarity:** Experienced teachers formulate overarching assessment criteria for “new” generic learning goals together with researchers and other stakeholders (Nielsen, 2015a).

- Enables deep teacher understanding of criteria and assessment practice for the learning goal (Nielsen, 2015b)
- Solid basis for changing wider assessment culture so as to better accommodate the learning goal (Nielsen, Tidemand & Dolin, 2018).

**Assessment practice:** Experienced teachers systematically implement different assessment methods for assessing the generic learning goal (Dolin, Nielsen & Tidemand, 2017).

- Micro-level insight into how the learning goal can be operationalised into constructs that can inform teaching and assessment (Nielsen, Tidemand & Dolin, 2018).
Thank you very much!

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References


References


References


