Why don’t we teach what we want students to learn?

Or

What is the secret of disciplinary and interdisciplinary expertise?

Fred Janssen
Teaching and learning after Covid-19

Teachers have to make two kinds of choices

What to teach?
• Content selection and organisation
• Content sequencing

How to teach?
• Method (didactiek)
• Media (techniek)

Focus during Covid-19

Reigeluth, 2007
What is our most important choice?

Although most of the action rotates around methods and media

Our most important choice is what we try to teach

Because many shortfalls we want to address by newer media and methods are often more a matter of what we try to teach

Schwab, 1969; Perkins, 1992; Shulman & Quinlan, 1996; Pellegrino, 2012; Janssen et al, 2019
What do we want students to learn?

Beyond remembering

Well-structured

Continuum

Ill-structured

Problem Solving

Simon, 1973; Jonassen, 2000; Ohlsson, 2012; Merrienboer, 2013; Reed, 2016; Law et al, 2020

Explaining ponytail motion

Plastic soup problem
What do we want students to learn?

Beyond remembering:

- **Well-structured problem solving**
- **Ill-structured problem solving**

- ✓ Asking important questions
- ✓ Developing (multiple) answers
- ✓ Testing answers in a critical way
- ✓ Making connections (within and between domains)
- ✓ Making responsible choices
- ✓ Learning how to learn
What is critical for problem solving?

Research on expertise shows:

**Not critical**
General Skills

**Most critical**
Knowledge Organisation

De Groot, 1946; Chi et al, 1981; Nokes et al, 2010; Tricot & Sweller, 2014; Gobet, 2016; Chi, 2016; Ericsson et al, 2018
Try to recall this position (5 sec)
De Groot’s seminal research on expertise (1946)

Illustrates the power of organising knowledge in meaningful patterns

De Groot, 1946; Gobet & Simon, 1996
Chi et al (1981)

Problem 7 (23)

Problem 7 (35)

Novice 1: “These deal with blocks on an incline plane”

Novice 5: “Inclined plane problems, coefficient of friction”

Novice 6: “Blocks on inclined planes with angles”

Diagrams Depicted from Problems Categorized by Experts within the Same Groups

Experts’ Explanations for Their Similarity Groupings

Problem 6 (21)

Expert 2: “Conservation of Energy”

They are all straight-forward problems.”

Expert 4: “These can be done from energy considerations. Either you should know the Principle of Conservation of Energy, or work is lost somewhere.”

Problem 7 (35)
How to organise knowledge for problem solving (1)?

Hierarchical organisation facilitates remembering and problem-solving.

Ausubel, 1968; Reif & Heller, 1982; De Jong & Ferguson, 1992; Reif, 2008; Giere, 2010
How to organise knowledge for problem solving (2)?

**Schematic** organisation facilitates problem-solving
(schema = variable-value structure)

Minsky, 1974; Barselou, 1992; Nokes et al, 2010; Wimsatt, 2007; Ohlsson, 2011; Thagard, 2012
How to organise knowledge for problem solving (3)?

**Question based organisation**

**Question agenda of developmental biology**

**The question of differentiation.** A single cell, the fertilized egg, gives rise to hundreds of different cell types … Since every cell of the body (with very few exceptions) contains the same set of genes, how can this identical set of genetic instructions produce different types of cells? How can a single cell … generate so many different cell types?

**The question of morphogenesis.** How can the cells in our body organize themselves into functional structures? …

**The question of growth.** … How do our cells know when to stop dividing? How is cell division so tightly regulated?

**The question of reproduction.** … How are germ cells set apart from the cells that are constructing the physical structures of the embryo, and what are the instructions in the nucleus and cytoplasm that allow them to form the next generation?

**The question of regeneration.** Some organisms can regenerate their entire body. … there are some cells in our bodies—stem cells—that are able to form new structures even in adults. How do the stem cells retain this capacity and can we harness it to cure debilitating diseases?

**The question of evolution.** … How do changes in development create new body forms? Which heritable changes are possible, given the constraints imposed by the necessity that the organism survive as it develops?

**The question of environmental regulation.** The development of many (perhaps all) organisms is influenced by cues from the environment that surrounds the embryo or larvae. … How is the development of an organism integrated into the larger context of its habitat? (Gilbert, 2010: 2–3)

Perspectives are a way to organise knowledge

- Which substance(s)?
- Which properties?
- Which type of particles?
- Which forces exist between the particles?
- How do the particles move?
- How are the particles organized?

Ethics

- What are interest groups (affected parties) relevant to the issue in question?
- What are possible courses of action?

- What is the impact of a course of action on all interest groups involved?
  - On wellbeing?
  - On fairness?
  - On autonomy?
The properties of substances can be explained by the nature of the particles of which it consists, the forces between them, and the movement and organization of those particles.
Perspectives for organising knowledge

Structure

Perspectives integrate
✓ Hierarchical organisation
✓ Schematic organisation
✓ Question based organisation

Function

☑ Remembering
☑ Well-structured problem solving
☑ Ill-structured problem solving
✓ Asking questions
✓ Developing answers
✓ Testing answers
✓ Making connections (within and between domains)
✓ Making responsible choices
✓ Learning how to learn

Biomedical perspective

How does a disease originate and how can it be treated?

• What are the complaints/ symptoms?
• How often, where and with whom does it occur?
• How does it normally function?
• What is going wrong?
  o Psychosocially
  o Physical damage
  o Pathogens
  o Auto-immune responses
  o Genetics
  o Nutrient deficiency
• How can it be treated?
• How can it be prevented?
Perspective for European Law

How to arrange free selling and buying for businesses and consumers in the EU?

• How to prevent that EU member states obstruct free movement of production factors?
  o Goods?
  o Services?
  o People (citizens and labor)?
  o Capital?

• How to prevent that businesses complicate buying and selling?

Armin Cuyvers

FdR
Perspective for European Law
Sjef Barbiers  FGW

Linquistic perspective

Markus Davidsen  FGW

Perspectives for building portfolios
• Mathematical (basic) perspective
• Statistical perspective
• Ethical perspective

Harald van Mill & Frans Rodenburg  FWN

Religious perspective  

LERVO-update

Een perspectiefgerichte benadering van het vakgebied Levensbeschouwing en Religie

JAN BOLLEMAAT, MARKUS DAVIDSEN, JAN VAN DIJK, MICHAËL VAN DER MEER
Four bachelor courses of molecular genetics
Molecular genetic perspective
Transforming school subjects into perspectives

Deel 2

Schoolvakken in perspectief

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What to teach (2)? Sequencing content

Atomistic sequencing
- Decompose a complex whole into pieces
- Teach it piece-by-piece
- Part-task practice

Hinders meaning making and problem solving

Holistic sequencing
- Progressive differentiation (expanding the perspective)
- Driven by interesting/relevant problems (whole tasks)

Facilitates meaning making and well- and ill-structured problem solving

Reigeluth, 2007;
Kirschner & Merrienboer, 2017
Janssen et al, 2019
Complex question

Why legs not wheels?
Evolutionary perspective
How to explain complex design in nature?

Darwin’s answer → cumulative selection

By gradual step-by-step transformations from simple beginnings, sufficiently simple to have come into existence by chance, directed by nonrandom survival and reproduction.
Stepwise expanding the perspective driven by complex questions providing the need or expansion
Mapping questions for team based learning on a biomedical perspective

Vraag 1
Hoe wordt huidkanker veroorzaakt?

Vraag 2
Hoe verloopt het ziektebeeld?

Vraag 3
Wat zijn de klachten/symptomen?
Welke vormen zijn er?
Hoe verloopt het ziektebeeld?

Vraag 4
Welke vormen zijn er?
Hoe kan huidkanker worden voorkomen?

Vraag 5
Hoe wordt huidkanker behandeld?

Vraag 6
Hoe kan het worden behandeld?
Hoe kan het worden voorkomen?

Huidkanker (epidemie)

Hoe vaak komt het voor?
Is er verschil tussen man/vrouw?
Is er verschil tussen leeftijdsgroep?
Is er verschil tussen mensens met bepaalde huidskleur?

Hoe worden de normale functies van de huid vervuld?

Wat gaat er mis?

Hoe wordt huidkanker veroorzaakt?

Hoe beschermt de huid tegen de zon?

Psychosociaal?

Wat is de rol van anti-zonnebrand?

Fysieke schade?

Wat gebeurt er in de cel?

Ziekte verwekkers?

Voedsel tekorten?

Autoimmuun?

Erfelijkheid?

Wat is onderliggend aan erfelijke huidkanker?

Zijn er voorlooper stadia?

Is er in te zetten op preventie?

Is een bruine tint gezond?

Zijn er opruimmechanismes?

Zijn er herstelmechanismes?

Hoe detecteer je dit?

Zijn er genetische testen?

Treden er genetische veranderingen op?

Hoe detecteer je dit?

Team based learning 1
Huidkankerepidemie
het probleem

Team based learning 2
Hoe wordt huidkanker veroorzaakt

Team based learning 3
Hoe wordt huidkanker behandeld

Team based learning 4
Hoe kan huidkanker worden voorkomen

Waarom zijn er huidskleur verschillen?

Hoe wordt pigment geproduceerd?

Ziekte verwekkers?

Erfelijkheid?

Wat is onderliggend aan erfelijke huidkanker?

Zijn er voorlooper stadia?

Is er in te zetten op preventie?

Hoe detecteer je dit?

Zijn er genetische testen?
Perspectives are essential domain specific tools for developing and organising knowledge. What happens if they are skipped?

- Students lack an advance organiser for meaningful learning
- Students lack powerful thinking tools for well-structured and ill-structured problem solving (both disciplinary and interdisciplinary)
- Students do not learn how to think like .....
Teaching and learning after Covid-19

Take-home message

• Our most important choice is what we try to teach.

• Organise and sequence content as one or multiple expanding perspectives to facilitate well- and ill-structured problem solving.

• Based on this robust backbone additional decisions about methods and media can be made.
Fred Janssen

- Master’s degree in Biology
- PhD ‘Learning biology by designing’
- ICLON, Leiden Graduate School for Teaching (since 1999)
  - Biology teacher educator (until 2016)
  - Full professor of science education (since 2016)
  - Department head secondary education (since 2018)
  - Senior Comenius Fellow / Leiden Teachers’ Academy fellow
- Scientific director ICLON (since 2022)
- Focus of my own research program (13 PhD’s / 2 Post-docs)

An ecological approach to student and teacher learning
# Interfacultair Centrum voor Lerarenopleiding, Onderwijsonderzoek en Nascholing (ICLON)

100+ onderwijsexperts

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- Goede universitaire, regionale, nationale en internationale verankering
- Opleiden, professionaliseren en onderzoek m.b.t. de gehele keten (po,vo, ho)
- Uitstekende beoordelingen van visitatiecommissies
- Werken vanuit een gemeenschappelijke kennisbasis
ICLON Knowledge base

12 Teaching - Learning principles

For understanding and supporting student and teacher agency development