Why we need to consider science for teaching mathematics.

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Mathematics and science in "emergency preparedness education"

Two perspectives:

- Why we need to consider science as a discipline (and a transposed discipline to be taught) when teaching mathematics (Chevallard, 2004)
- Why we need to consider the teaching of mathematics as a science.

Taking a moment to review and reflect on the interplay between the (teaching-)disciplines of science and mathematics.

- Maybe we just do it – it is so "obviously" a good idea!

The obvious connections between math and science in relation to the conference theme.

- Nature (and to some extend cultivated nature) presents us with some challenges which are well suited as basis for good lessons
  - Intrinsic motivation (close to, or far from students world)
  - Clear relevance to society
  - Patterns and regularities

Different epistemological frameworks

When we look at the lessons we have seen and the textbook materials we have produced, what will the students have opportunity to learn?

Is topics related to volcanic eruption and fire “just” a convenient thematic in which to learn so called real mathematics?

Is science “just” a convenient starting point to leave behind when we enter mathematics, after we have done the mathematizing? (e.g. Formatting reality to become suitable for mathematical modelling)

Some characteristics of mathematics as a discipline:
- Hypothetical-deductive
- Proofs are possible

Some characteristics of science as a discipline:
- Empirical-inductive
- Falsifiable (in principle)

The ambiguities of interdisciplinary teaching

Educational research has not reached consensus (in terminology)

- Inter disciplinary
- Multi disciplinary
- Integrated
- Cross disciplinary
- Trans disciplinary
- Thematic
- Blended
- Etc...

Borders more or less cancelled between disciplines

a cooperation with clear delimitation of the individual disciplines (Andresen & Lindenskov, 2009)

A mix with visible boundaries

No clear distinction between disciplines (Matthews, Adams, & Goos, 2009)

"Anthropologists' first rule:
Do not be mislead by names"

Constraints and affordances to teaching in an interdisciplinary fashion

Institutional constraints:

- Teachers alone in the classroom
- Teachers educated in disjoint disciplines

Affordances (some of them more believed than known):

- Synergy (“why”)
  - Efficient (“Faster”)
  - Effective (“Better”) (Dorn et al. 2005)
- Meaningfulness (“why”)
  - “Real life” relation
  - Utilitarian meaning
  - ...others
  - ...others

What knowledge should the interdisciplinary teacher posess?

A science acquires knowledge of the world
• Objective → inter subjective → consensus
•That is verification should be
- •Repeatable
- •Across different methods
- •Generally accepted

•Lesson Study might qualify as a science (or a scientific method to acquire knowledge about the world of teaching)

•Some lesson studies are by necessity interdisciplinary

- MKT, PCK, in the moment pedagogies, etc. (Mason & Davis, 2013, Shulman, 1986)

- Knowledge from the sciences
- Knowledge of math and science ontology and epistemology

There seems to be *too* many "forms" of knowledge involved

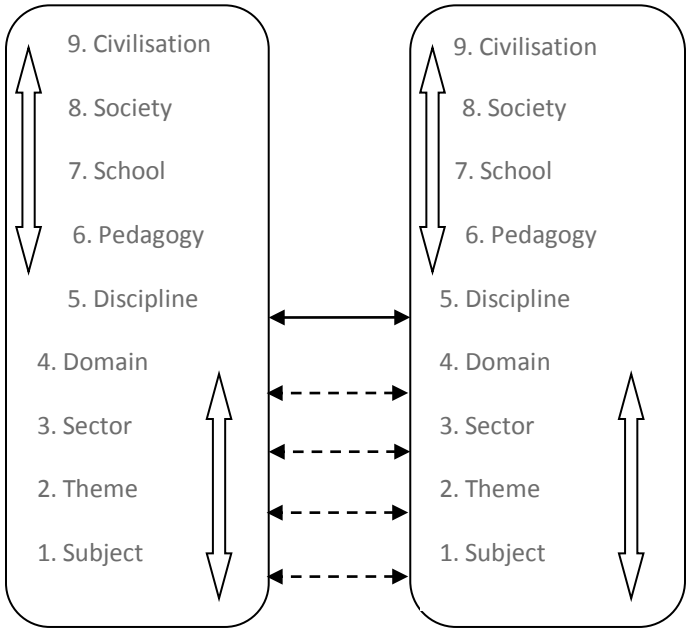
- And this leads me to consider and introduce praxeologies

An example of considering science and mathematics teaching together

- From the Advanced Science Teacher Education-project
- Described using the levels of didactic codetermination from the Anthropological Theory of Didactics (ATD) (Winsløw, 2011)

Praxeologies:

- Task
- Technique
- Technology
- Theory



Levels of co-determination for a bi-disciplinary ecology

"Anthropologists' first rule:
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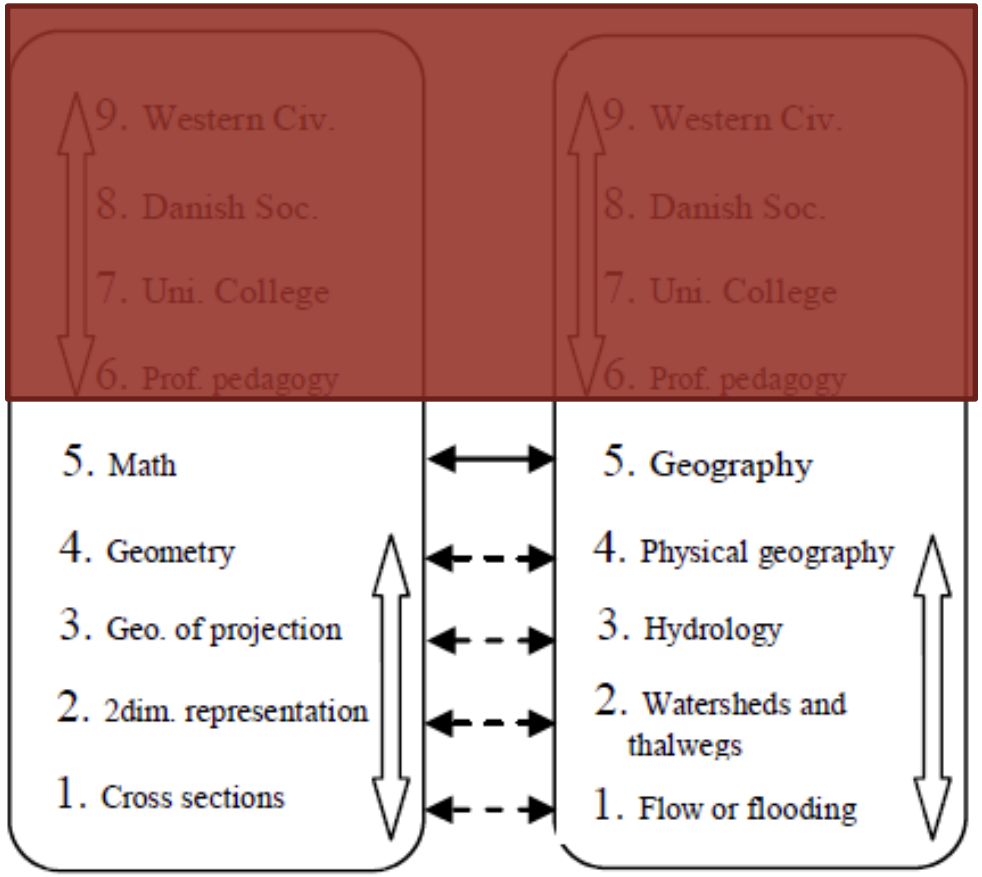
Considering science and mathematics teaching together – GIS, data analysis and modelling in geography

- Bridging Concepts (Wake 2011)
  - Flow (of many kinds)
  - (Maps)

- The codetermination can be used to trace how bridging concepts actually work (and thus becomes the bridge enabling a teaching meaningful to both disciplines (Rasmussen & Winsløw, 2013)



Bringing it together

- Math and science can be utilised to justify each other, if suitable "connections" are identified. (e.g. Bridging concepts)
- Each teaching discipline should *genuinely benefit* from the other, or else nothing is gained.
- "Emergency preparedness education" appears well suited to act as an interdisciplinary "field" in which (curricular items from) mathematics and science can be taught.
- If "Emergency preparedness education" is to be taught as part of math or science, we must be able to point out which curricular items it helps cover.
- We can use Lesson Study "scientifically" to investigate if, and how, the above outlined holds any truth.

References

Andresen, M., & Lindenskov, L. (2009). New roles for mathematics in multi-disciplinary, upper secondary school projects. *ZDM, 41*(1), 213-222. doi: 10.1007/s11858-008-0122-z

Chevallard, Y. (2004). La place des mathématiques vivantes dans l'éducation secondaire: transposition didactique des mathématiques et nouvelle épistémologie scolaire.'. In C. Ducourtioux & P. L. Hennequin (Eds.), *La place des mathématiques vivantes dans l'éducation secondaire* (pp. 239-263). Paris: APMEP.

Dorn, R. I., Douglass, J., Ekiss, G. O., Trapido-lurie, B., Comeaux, M., Mings, R., . . . Ramakrishna, B. (2005). Learning Geography Promotes Learning Math: Results and Implications of Arizona's GeoMath Grade K-8 Program. *Journal of Geography, 104*(4), 151-160.

Mason, J., & Davis, B. (2013). The Importance og Teachers' Mathematical Awareness for In-the-Moment Pedagogy. *Canadian Journal of Science, Mathematics and Technology 13*(2), 182-197.

Matthews, K. E., Adams, P., & Goos, M. (2009). Putting it into perspective: mathematics in the undergraduate science curriculum. *International Journal of Mathematical Education in Science and Technology, 40*(7), 891-902. doi: 10.1080/00207390903199244

Rasmussen, K., & Winsløw, C. (2013). *Didactic Codetermination in the Creation of an Integrated Math and Science Teacher Education: The Case of Mathematics and Geography*. Paper presented at the CERME 8, Antalya.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4-14.

Wake, G. (2011). *Modelling In An Integrated Mathematics And Science Curriculum: Bridging The Divide.* Paper presented at the CERME 7, Rzeszow, Poland.

Winsløw, C. (2011). *Anthropological theory of didactic phenomena: Some examples and principles of its use in the study of mathematics education.* Paper presented at the III Congreso Internacional sobre la TAD, Barcelona.

Thank you for your attention.