Development of an Empirically Grounded Learning Performances Framework for Primary Students‘ Modeling Competence of Water

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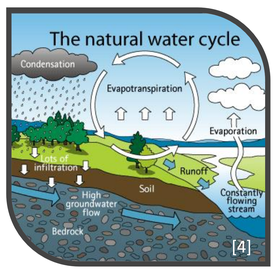
INTRODUCTION

My dissertation project focuses on developing and refining a Learning Performances Framework for primary students‘ modeling competence. This framework aims to provide a coherent means to describe and investigate early learners‘ knowledge across modeling practices, related epistemic considerations and disciplinary concepts (e.g. water cycle) in order to promote and support modeling-based teaching and learning already at the primary school level.

THEORETICAL BACKGROUND

Scientific Models

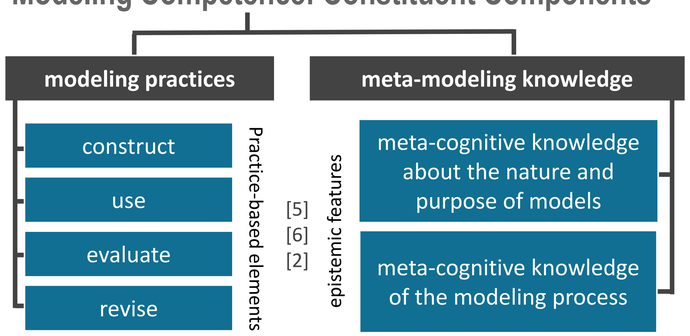
…are abstracted, multi-modal reconstructions of systems, not exact recreations, to illustrate, predict.and/ or explain system-specific phenomena [1].



Scientific models as (e.g. [2], [3])

- **representations** of phenomena, systems etc. (e.g. communicate knowledge; explain relationships)
- **sense-making tools** (e.g. generate new knowledge; build hypotheses)

Modeling Competence: Constituent Components



Learning Performances

- help define observable outcomes for students in terms of performances through which complex, latent constructs, i.e. modeling competence can be made evident [7]
- provide a tool for guiding assessment opportunities [8]
- consistent with contemporary science standards [9], [10]

RESEARCH OBJECTIVE(S)

How can primary students’ integrated conceptual, epistemic and practice-based dimensions of modeling competence be adequately described and investigated?

DESIGN AND METHODS

The road so far…

Development of a theoretical Learning Performances Framework (LPF) [1] for primary students’ modeling competence integrating three core dimensions [9], [10]

(1) Content - a domain-specific, complex system to situate modeling (e.g. the water cycle)

(2) Modeling practices - engagement in/application of modeling with content

(3) Epistemic considerations - characterize students’ meta-knowledge about scienti-fic modeling (*nature of models*: evidence-based, appropriately detailed, generalizable; *purpose of models*: predict/hypothesize, explain, organize, generate)

Exemplary 6 (out of 21) learning performances lying at the intersections of the LPF’s constituent three core dimensions ‘content‘ (disciplinary concepts), ‘epistemic considerations‘, ‘modeling practices‘

		MODELING PRACTICES		
		Construct/Revise	Use	Evaluate
EPISTEMIC CONSIDERATIONS	Nature of Models (A model is…)			
	Evidence-based	Learner constructs or revises a model that incorporates evidence about a phenomenon	Learner uses a model to incorporate new evidence about a phenomenon	Learner evaluates a model based on the evidence provided/ gathered about the phenomenon
	Purpose of Models (A model is for…)			
	Explain (whole/ part)	Learner constructs or revises a model that aids in explaining some or all of a phenomenon	Learner uses a model to explain some or all of a phenomenon	Learner evaluates a models’ explanation of a phenomenon

Current phase

Goal: empirically ground and refine (saturate) the framework

Explorative Qualitative Research Approach

Use of Evidence-Centered Design (ECD) [8] to

- guide/inform development of model-centered (cognitive/performative) tasks using the learning performances of the LPF as a series of (discrete) claims
- implement (+ iteratively refine) the tasks to elicit evidence of these claims
- link observations in what students do/say to suggestions of what they understand or know [9]

Data collection and analysis (2nd cycle)

- Implementation of model-centered tasks embedded in a semi-structured interview protocol
- Individual student interviews (*N*=24) in 3rd/4th grade
- Transcription of audio-recorded interviews
- Qualitative analysis [11] in MAXQDA using *a priori* codes derived from the LPF (~70% double-coded)

Task example: evaluation of 3 varyingly complex water cycle models

PRELIMINARY FINDINGS

- Students were able to engage in most areas of the LPF targeted by the implemented tasks
- Limited robust evidence regarding the more abstract/complex purposes of models (e.g. prediction)
- Saturation not reached (yet) (→ refinement of tasks!)
- Variety of complexity in students‘ answers allowed first tentative generation of different levels within some of the learning performances (LPF refinement)

Learning performance levels for students‘ consideration for ‘appropriately detailed/complex models (epistemic consideration)‘, ‘evaluation (modeling practice)‘ and water-related concepts

Lvl	Description	Student example(s)
1	Learner looks specifically at the number of concrete elements represented - labels/ words/ numbers	*"This one has lots of words.“ / "It has all the names of things."*
2	Learner looks at both concrete and abstract elements and sometimes interpret meaning	*"It has more labels and it has more like this one has, like those signs* [symbols]."
3	Learner looks at the abstract elements of the model including how they are related to the concrete elements, discussing how those elements are connected.	*"We are seeing what is happening, how* [water] *moves." "These arrows mean the stuff is moving into the clouds ... "*

REFERENCES

https://www.dropbox.com/sh/quh4qcyllv3arai/AAA8muDMyCubuam0ITFOWIVfa?dl=0