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► **To cite this version:**

Yannis Liakos. Mathematical modeling and competencies for biology students. CERME 10, Feb 2017, Dublin, Ireland. hal-01933416

HAL Id: hal-01933416

<https://hal.science/hal-01933416v1>

Submitted on 23 Nov 2018

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Mathematical modeling and competencies for biology students

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The research aims at introducing modeling tasks with an ultimate goal to engage students more actively into learning mathematics through tasks that are biologically ‘colored’. My focus is on the individual progression (if any) of students’ mathematical competencies during a sequence of modeling sessions as part of their first year mathematics. My goal is to explore the nature of progression within the competency profile of participating student, the relation between modeling processes and this progression and what transformations are applied in these sets of competencies.

Keywords: Mathematical modeling, mathematical competencies, tasks, progression.

Short description of the research topic

The literature provides documentation of learning benefits by engaging students in mathematical modeling: educational benefits (Kaiser et al., 2006); students engaged in modeling may develop a deep understanding of the content and an ability to solve novel problems and that it can bring students into alignment with the epistemic aims of science and help them develop more sophisticated ideas within the area of study they are focused on. I adopt a design based research approach in which an iterative process of design, implementation and analysis takes place.

The research questions

RQ_1) What is the nature of progression in a student’s competency profile through the course of the mathematical modeling unit?

RQ_2) Considering a set of competencies (competency profile) as a body of knowledge, what transformations are applied in the course of the modeling sessions?

Theoretical and methodological framework

My theoretical approach is informed by the anthropological theory of the didactic (Bosch & Gascón 2014) and, in particular, by the distinction between four bodies of knowledge: scholarly knowledge; knowledge to be taught; knowledge taught; and knowledge learnt. A significant work on mathematical and modeling competencies has been done by many researchers (e.g. Maaß 2006; Blum & Kaiser 1997) while Niss (2003) created an 8-fold (KOM project) system of mathematical competencies. I decided to proceed to an adaptation of the KOM model adjusted to the above mentioned literature and the specific context I am working on: students of a Biology Department. Part of my analysis will be based a 3-D (radius of action, degree of coverage and technical level) model of progression for each competency from Niss and Højgaard (2011). I have also constructed a coding system in order to “attach” specific students’ expressions to a certain mathematical competency. These constructs form a first set of tools for data collection and analysis.

The context and methods for data generation and analysis

The context (or arena) of this study is the Biology Department of a Norwegian university and a mathematics course for first year Biology students. My main study took place with first year Biology students. Modeling sessions occur weekly during the first semester. These sessions (for groups of 3 to 4 students) are 50 minute in length and supplement lectures to the whole cohort of students. Tasks in the sessions are designed in five 2-week blocks focused on a subset of mathematical competencies that students should bring into action in order to complete the task.

To address RQ_1 I will, as above, explore selected students' small group discourse activity. Data were collected through audio-visual recordings of students working on tasks synchronized with their writing (using Smartpens which records audio and visual data accompanying written data). At RQ_2

I am addressing the question: what is the "offered body of competencies" (an a-priori analysis). For the next three steps I will use my data to provide answers or useful directions. A task-design analysis, for example, can provide what the existing literature provides on population dynamics and exponential growth (scholarly knowledge) but also which task was finally decided to be presented (knowledge to be taught) and this will happen for every different modeling block.

Potential significance and contribution

My research will contribute to the following areas (1) dynamic competencies profiles for students, (2) a critique of Niss' (2003) 8-fold system of mathematical competencies, and (3) a description, in the context of mathematical modeling in the Biological Science, of ATD's four bodies of knowledge.

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