MatRIC Centre for Research, Innovation and Coordination of Mathematics Teaching

Centre of Excellence in Education

The mathematical discourse of biology students working with mathematical modelling activities – a commognitive perspective

Olov Viirman & Elena Nardi

UNIVERSITY OF AGDER

In collaboration with:

NTNU – Trondheim Norwegian University of Science and Technology

Matematikksenteret Nasjonalt senter for matematikk i opplæringen

NMBU Norwegian University of Life Sciences

A collaborative project…

- MatRIC
  - Centre for excellence in mathematics education
  - University of Agder
- 
  - Centre for excellence in biology education
  - University of Bergen, Institute of Marine Research and University Centre in Svalbard.

…about mathematics for biology students…

- “The need for basic mathematical … literacy among biologists has never been greater.” (Gross, Brent & Hoy 2004)
- “Mathematics is biology’s next microscope, only better; Biology is mathematics’ next physics, only better.” (Cohen 2004)
- “Biology education is burdened by habits from a past where biology was seen as a safe harbour for math-averse science students.” (Steen 2005)

…using mathematical modelling

- “Concepts from biology should be integrated within the quantitative courses that life science students take.” (Gross, Brent & Hoy 2004)
- Mathematical modelling is a basic scientific skill within the “core competencies and disciplinary practices” of biology. (Brewer & Smith 2011)

Aim of the project

- increase biology students'
  - motivation for
  - interest in
  - perceived relevance of

  studying mathematics, through the use of mathematical modelling

A developmental research project

- Two phases (so far)
  - Phase 1 (pilot)
    - 10 students (first and second year biology students)
    - 1 meeting (April 2015)
  - Phase 2
    - 12 students (first semester biology students)
    - 4 meetings (Sept-Nov 2015)
- Three-hour meetings
- Centred around groupwork on mathematical modelling tasks with biological content
- Groups of 3-5 students

Example tasks

- Using data on roadkill to estimate the density of a rabbit population
- Using data on the relationship between femur circumference and body weight among various bird species to estimate the weight of an extinct species of bird
- Using data on the growth of a yeast culture to construct a model of yeast growth, and then using the model to predict future behaviour of the yeast culture

Data

- Questionnaires at the beginning and end of the first meeting
- Video and audio recordings of all sessions
- Informal interviews with students

The present study

- Aim: Investigating the mathematical discourse of the students as they engage in the MM activities
- A discourse analysis using commognitive methodology

Theoretical interlude – commognition (Sfard 2008)

- A discursive theoretical framework for studying thinking, and in particular mathematical thinking, teaching and learning
- Different forms of communication, characterizing particular communities, are called discourses
- Learning is change in one's participation in discourse

Theoretical interlude (cont'd)

What characterizes different discourses?

- Word use
- Visual mediators
- (Endorsed) narratives
- Routines

Theoretical interlude (cont'd)

- Routines are repetitive patterns in the discourse
- Sfard distinguishes between three types of routines
  - Explorations – aimed at producing new endorsed narratives
  - Deeds – aimed at change in objects (concrete or discursive)
  - Rituals – aimed at gaining social approval

Theoretical interlude (concluded)

- Explorations
  - Deals with mathematical objects and their realizations
  - Flexible routines, narratives built upon previously established discourse
  - Relies on internal authority and the rules of the discourse
  - Focuses on the mathematical narrative
- Rituals
  - Deals with symbols unrelated to the mathematical objects
  - Rigid routines weakly connected to previously established routines
  - Relies on external authority only
  - Focuses on the steps and procedures of the activity

Yeast growth – subtask one

- The students were given a table of measurements of the biomass in a yeast culture – biomass at time t and change at time t. They were then asked to:
  - Analyze the data in the table
  - Plot the data and analyze the graph
  - Suggest a simple model based on a difference equation of the form $\Delta p_n = k p_n$
  - Discuss the predictive power of the model constructed

Subtask two (intended)

- The students were given a continuation of the table, showing a gradual decrease in the change. They were then asked to:
  - Analyze the data in the new portion of the table
  - Plot population against time, explore the shape of the graph, and predict what will happen in the long run
  - Estimate the value of the carrying capacity
- However...

Subtask two (actual)

- The students were given a continuation of the table, showing a gradual decrease in the change. They were also supplied with a suggested non-linear model $\Delta p_n = k_2 p_n (665 - p_n)$, and asked to
  - Test the new model by plotting Δp_n against $k_2 p_n (665 - p_n)$
  - Check for proportionality
  - Estimate the proportionality constant

Subtask three

- Given a value for the proportionality constant of k_2=0,00082, use the model to compute twelve values of p_n starting with p_0=9,6, and compare with the values in the table.

The work of group 2 – description and analysis

- Subtask one
  - Focus on the details of constructing the graphs, little consideration of the goals of the activity
  - The meaning of the symbols used, and their connection to the data, remains unclear
  - Instead of plotting change against amount they plot amount against time, but still try to fit a straight line to the graph
- Conclusion – evidence of ritualized routine use

The work of group 2 – description and analysis

- Subtask two
  - The work still revolves around graph construction
  - Confusion around the interpretation of data – decrease in Δp_n interpreted as decline in population
  - Some evidence of awareness of the meaning of symbols: ”But this is just the change, not the number of living cells.”
  - Still, the graph constructed plots change against time, despite the clear instruction
- Still mostly ritualized routine use

The work of group 2 – description and analysis

- Subtask three
  - With the focus of the task no longer being graph construction, the students are at a loss at how to proceed: ”I don’t have a clue. I feel so stupid.”
  - The routines they have available are not sufficient for moving from model construction to model validation
  - After getting started on the computational work, they still spend considerable time plotting the computed values, despite this not being helpful for solving the task
- Again evidence of ritualized routine use

Possible conclusions

- The subtasks are formulated in a manner that decreases student agency by specifying very clearly what the students are supposed to do
- Perhaps this focus on the doing rather than the aims leads to an increasingly ritualized routine use

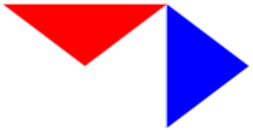
- So, a sad tale...?

Perhaps not!

- Events in the next session (still to be properly analyzed) suggest that the ritualized routine use in this session still paved the way for a more exploratory discourse
- The group's work on a related but different task, on the decay of a drug in the bloodstream, shows indications of this
- This task was not divided into subtasks, lending additional support to the idea of a connection between decreased student agency and ritualized routine use

Hence…

- If we want to encourage exploratory discourse, then tasks need to be designed in a way that does not put too much focus on the doing



Senter for
fremragende
utdanning

Thank you for listening!