

# Assessing the Development of Students' Mathematical Modeling Competencies: An Information Entropy Approach

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*We suggest a new scaling tool for converting big amounts of qualitative data into quantitative data based on the recent developments in the information theory. We believe that it can be used with reasonable efficiency to monitor the development of students' mathematical competencies, and not only. Discussing advantages and shortcomings of this tool along with the possibilities for further development, we invite to discussion of a new approach.*

Keywords: mathematical modeling, competencies, quantitative data, evaluation tool, information entropy.

## Description of the methodology

We introduced mathematical modeling tasks with biological content to engage biology students more actively into learning mathematics and created mathematical competencies profiles for individual learners to follow their development from session to session. From a wide selection of approaches to the notion of mathematical competencies reported in the literature (Maaß, 2006, Boesen et al, 2014, Weinert, 2001), we chose a competency framework from the Danish KOM project (Niss, 2003). Viewing a competency as an individual's ability to use mathematical concepts in a variety of situations, within and outside of the normal realm of mathematics (Niss, 2003), we retain five basic groups of mathematical competencies out of the eight suggested in KOM: thinking/acting mathematically, modeling mathematically, representing and manipulating symbolic forms, communicating/reasoning mathematically, and making use of aids and tools. Fifteen competencies in five groups are coded separately in a reliable manner. When the data collected in the sessions are coded, the record of each competency frequency and strength (beginning, intermediate, developed, exemplary) is being kept. This creates big data sets which we would like to analyze in order to assess and monitor students' competency development. To this end, we rely on a so-called Shannon entropy (information entropy), one of the central concepts in the information theory. Our approach to the competencies development evaluation combines Shannon's entropy and VIKOR method developed for finding closest to an ideal solution to decision problems with conflicting and noncommensurable criteria. Our research questions in this study are: 1) How can large amounts of qualitative data be converted into quantitative data by using the tools from modern information theory? 2) How reliable and efficient is this new scaling tool?

## Conclusions

We believe that a new entropy-based scaling tool opens new interesting opportunities for researchers who need a consolidated evaluation for big amounts of data; it could be efficiently used both to monitor the development of individual students' competencies and to compare their performance. It allows to assign different weights to competencies providing thus possibilities for monitoring the progress in the development of particular skills. However, using this method of data analysis inevitably leads to the loss of some essential information, the risk we are willing to undertake in order to study the potential of this new progress-tracking tool.

## References

- Boesen, J., Helenius, O., Bergqvist, E., Bergqvist, T., Lithner, J., Palm, T., & Palmberg, B. (2014). Developing mathematical competence: From the intended to the enacted curriculum. *The Journal of Mathematical Behavior*, 33, 72-87.
- Maaß, K. (2006). What are modelling competencies? *Zentralblatt für Didaktik der Mathematik*, vol. 38(2), 113-142.
- Niss, M. (2003). Mathematical competencies and the learning of mathematics: The Danish KOM project. In Gagatsis, A., & Papastavridis, S. (eds.), *3rd Mediterranean Conference on Mathematical Education* (pp. 115-124). Athens, Greece: Hellenic Mathematical Society and Cyprus Mathematical Society.
- Opricović, S. (1990). Programski paket VIKOR za visekriterijumsko kompromisno rangiranje, SYM-OP-IS.
- Weinert, F. E. (2001). Vergleichende Leistungsmessung in Schulen - eine umstrittene Selbstverständlichkeit. In F. E. Weinert (Ed.), *Leistungsmessung in Schulen* (pp. 17-31). Weinheim, Basel: Beltz Verlag.