Theory-related pedagogical content knowledge for teaching simulations and mathematical modelling with digital tools – empirical analysis of the promotion of pre-service teachers

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Introduction

- Digital tools can support students' simulation and modelling processes in many ways.

  (Geiger, 2011; Greefrath & Siller, 2017)

- In order to use this potential profitably in the classroom, teachers need specific professional competences.

  (Baumert & Kunter, 2013; Blömeke et al., 2015; Drijvers et al., 2016)

- The theory-related pedagogical content knowledge is one cognitive competence dimension of the necessary professional competence for teaching simulations and mathematical modelling with digital tools.

  (Gerber et al., 2022)

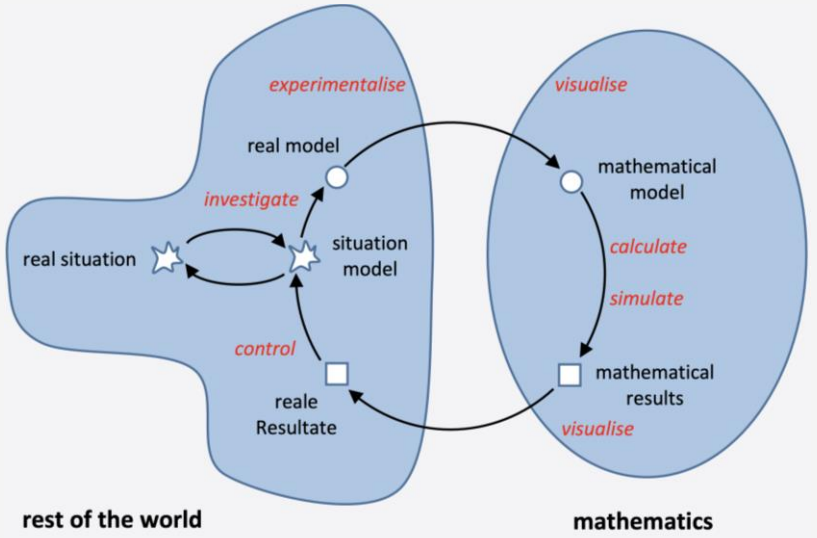
Theory & Research Question

- **Theory-related pedagogical content knowledge** for teaching simulations and mathematical modelling with digital tools
  - declarative meta-knowledge
  - background knowledge about aims, perspectives and potentials

  of using digital tools in reality-based lessons.

  (Gerber et al., 2022) (cf. also Borromeo Ferri, 2018)

- Declarative meta-knowledge also includes modelling cycles that take the use of digital tools into account.

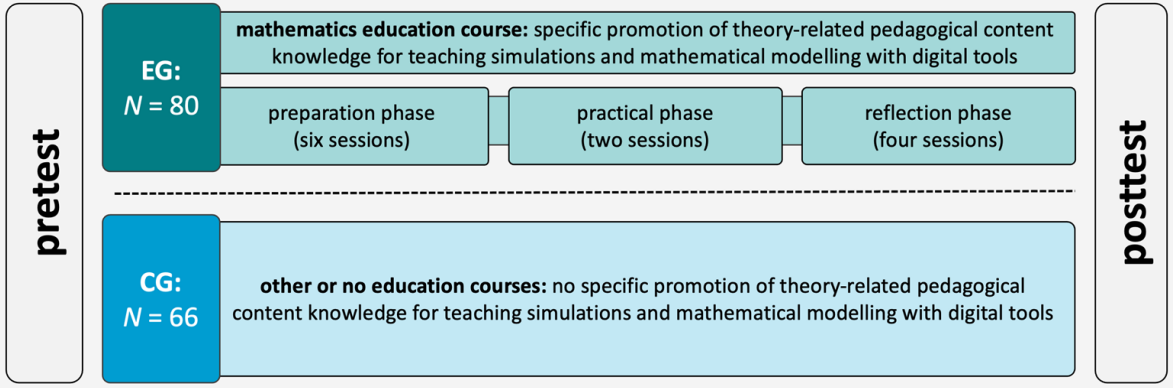


(Greefrath, 2011, p. 303)

RQ: *To what extent can the **theory-related pedagogical content knowledge** for teaching simulations and mathematical modelling with digital tools of pre-service mathematics teacher be **developed by a university mathematics education course** with practical elements conceived by us?*

Research Design & Test Instrument

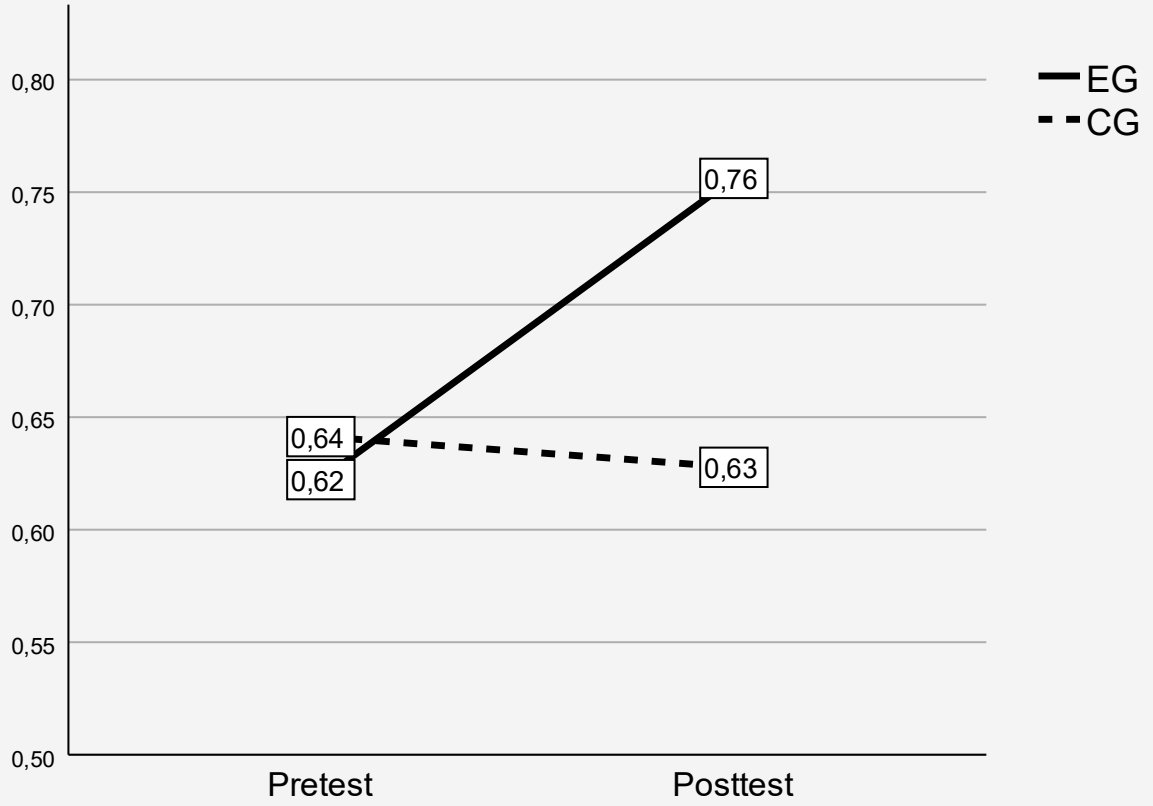
- quasi-experimental intervention study with an experimental group (EG) and a control group (CG)
- data from 146 pre-service mathematics teachers at University of Münster and University of Würzburg
- 9 items in a multiple-choice answer format, items are evaluated dichotomously
- example item:
  (see Gerber et al., 2022, p. 1054)



The use of digital tools …	
… requires a standardized approach to mathematical modelling.	☐
… in mathematical modelling is only possible in calculation.	☐
… makes it possible to work on mathematical models with complex function terms.	☒
… is not helpful in understanding the factual context.	☐

Results

- Development of the knowledge differs significantly between the groups, $t(144) = 4.238$, $p = .001$, $d = .71$
- Knowledge in the experimental group: significantly increasing, $t(79) = 5.954$, $p = .001$, $d = .67$
- Knowledge in the control group: not significant decreasing, $t(65) = -.506$, $p = .614$



Discussion

RQ: *To what extent can the **theory-related pedagogical content knowledge** for teaching simulations and mathematical modelling with digital tools of pre-service mathematics teacher be **developed by a university mathematics education course** with practical elements conceived by us?*

- The effectiveness of the presented course, which served as an intervention, could be confirmed.
- This suggests that the course concept with its three-part division (preparation, practice and reflection phase) and practical school elements was chosen sensibly.
- At the same time, it has not yet been determined which elements of the course design were (particularly) responsible for the individual knowledge gains, as the intervention was only investigated as a whole.

References I

Baumert, J., & Kunter, M. (2013). The COACTIV model of teachers' professional competence. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, & M. Neubrand (eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers: Results from the COACTIV project* (p. 25–48). Springer US.

Blömeke, S., Gustafsson, J.-E., & Shavelson, R. J. (2015). Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie*, *223*(1), 3–13. https://doi.org/10.1027/2151-2604/a000194

Borromeo Ferri, R. (2018). *Learning how to teach mathematical modeling in school and teacher education*. Springer International Publishing.

Drijvers, P., Ball, L., Barzel, B., Heid, M. K., Cao, Y., & Maschietto, M. (2016). *Uses of technology in lower secondary mathematics education: A concise topical survey*. Springer International Publishing.

References II

Geiger, V. (2011). Factors affecting teachers' adoption of innovative practices with technology and mathematical modelling. In G. Kaiser, W. Blum, R. Borromeo Ferri, & G. Stillman (eds.), *Trends in Teaching and Learning of Mathematical Modelling* (p. 305–314). Springer Netherlands.

Gerber, S., Quarder, J., Greefrath, G., & Siller, H.-S. (2022). Pre-service teachers' pedagogical content knowledge for teaching simulations and mathematical modelling with digital tools. In J. Hodgen, E. Geraniou, G. Bolondi, & F. Ferretti (eds.), *Proceedings of the Twelfth Congress of the European Research Society in Mathematics Education (CERME12)* (p. 1051–1058). ERME / Free University of Bozen-Bolzano.

Greefrath, G. (2011). Using technologies. New possibilities of teaching and learning modelling – Overview. In G. Kaiser, W. Blum, R. Borromeo Ferri, & G. Stillman (eds.), *Trends in Teaching and Learning of Mathematical Modelling: ICTMA14* (p. 301–304). Springer.

References III

Greefrath, G., & Siller, H.-S. (2017). Modelling and simulation with the help of digital tools. In G. A. Stillman, W. Blum, & G. Kaiser (eds.), *Mathematical Modelling and Applications* (p. 529–539). Springer International Publishing.