Characterizing mathematics lessons via task characteristics

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Abstract

For teachers, tasks are an effective way to structure the content and the form of a lesson. In addition, tasks are the main opportunity for the students to engage with mathematical concepts and procedures during the lesson. Hence, the type of tasks predominantly used throughout the course of a lesson and the way in which students engage with them are likely to influence the lesson as a whole. As such, tasks and task characteristics have been used as indicators for different aspects of teaching and teaching quality. The present study aims to investigate the extent to which different dimensions of teaching quality are influenced by the kind of tasks that the teachers employed in their classrooms.

Within the TEDS-Validate research project, trained raters observed and rated the instructional quality of mathematics lessons in different parts of Germany using an observation protocol devised for the TEDS-Instruct study. In addition, all tasks employed throughout the course of the lessons were sampled and analyzed using the task classification scheme from the TEDS-Validate study. In total, 31 teachers participated in all parts the study, including measurements of their mathematical and pedagogical competences and beliefs. In order to gain a better understanding of the sample consisting of 2500 mathematical tasks, a latent class analysis focusing on the six general mathematical competences (modelling, problem solving, reasoning and argumentation, use of representations, use of symbols and formalisms and mathematical communication) was carried out. The results show that the tasks can be divided into four distinctive groups highlighting different of the aforementioned competences. Further analysis are planned to investigate the distribution of the different types of tasks across lessons and teachers as well as correlations with other aspects of the teacher and the mathematical instruction.

Extended Summary

The quality of (mathematics) instruction is considered in many studies as a stable and reliable predictor for cognitive achievement and student motivation (Blömeke & Olsen, 2019; Scherer & Nilsen, 2016). The measurement of a construct as complex and multi-dimensional as teaching quality, however, remains a methodological issue that is still widely discussed among researchers. Largely varying assessments of the same lesson from different perspectives (student/teacher/external observer or general/content-specific viewpoint), the use of different rating manuals and questionnaires as well as the problem of comparability across countries and cultures cannot be ignored (Bellens et al., 2019; Blazar et al., 2017; Fischer et al., 2019). It may therefore be desirable to combine different strategies and measurements to analyzing teaching quality for a more holistic approach.

The integration of classroom artifacts such as student work, tasks and lesson plans seems to be a viable and promising endeavor that can contribute to a better understanding of the practices in a classroom and the underlying quality of a given lesson (Boston, 2012). The mathematical tasks in particular, which are often at the center of the teachers' and students' activities before, during and after a lesson as well as for the assessment of students' learning gains are used as indicators for the potential of cognitive activation in several studies (Baumert et al., 2010; Herbert & Schweig, 2021). While there is still limited research on the exact link between classroom artifacts and different aspects of teaching quality, studies suggest that they are highly correlated with the observed instruction and can be used as stable indicators of classroom practice (Borko et al., 2005; Clare & Aschbacher, 2001). While the analysis of classroom artifacts is often less expensive and easier to realize than classroom observations or surveys, they are limited in the way that tasks and lesson plans only reveal the intended potential for cognitive activation and disregard the actual implementation and realization of said potential (Herbert & Schweig, 2021). The goal of this research project is therefore not to establish the analysis of mathematical tasks as an alternative but as an enrichment for other forms of measurement such as classroom observations.

The present study is situated in the TEDS-M research program alongside the studies TEDS-Instruct and TEDS-Validate (*Teacher Education and Development Study*), which focus on relations between mathematics teachers' professional competences and their students' learning gains (Kaiser et al. 2017). In this context, the quality of both the teaching and the tasks from the classrooms are interpreted as mediating variables between the teacher and the students' learning activities. The instructional quality was assessed based on the classroom observation protocol developed in the context of the study TEDS-Instruct (Schlesinger et al. 2018). It comprises various items from three generic dimensions – that is classroom management, cognitive activation and student support (Klieme & Rakoczy 2008) – as well as subject-specific items of instructional quality. In addition, all mathematical tasks set by the 31 participating teachers throughout the observed lessons were collected resulting in a total sample of approximately 2500 tasks. A classification scheme for the rational analysis of the tasks was developed for the TEDS-Validate study based mainly on prior work from COACTIV (Jordan et al., 2006) and PISA (Turner et al, 2015). The tasks were then rated with regard to the underlying mathematical concepts and ideas, the procedural characteristics of doing mathematics as well as the cognitive and linguistic complexity using mainly four-point ordinal scales.

The overall results confirm the findings from the COACTIV project showing that the majority of mathematical tasks from German classrooms offer little potential for cognitive activation (Neubrand et al., 2013). Only a small number of tasks from the sample encourage more complex modelling activities or require the students to give reasons and explanations. In order to gain a better understanding of the tasks constituting the sample, a latent class analysis focusing on the extent to which the task fosters different mathematical competences was carried out using Mplus (Muthén & Muthén, 2017; Vermunt & Magidson, 2002). While both the model consisting of four and of six classes

fit the data equally well, the more economic model was also easier to interpret and thus, the 4-class model was selected for further analysis. The four classes that could be extracted from the data by this means showed different foci regarding the mathematical competences necessary to solve the tasks. On average, tasks from the first class (n=1104) scored the lowest out of all classes (below 0,2 on a scale from 0 to 3) in all dimensions except for the use of symbols and formalisms. Due to the large number of tasks falling into this class, this trend can also be observed for the entirety of the sample. The second class (n=410) shows a clear focus on mathematical communication with the highest scores in this dimension as well as the highest average score for mathematical modelling. In comparison, the tasks from the third class (n=833) require an elaborate use of different mathematical representations while scoring the lowest out of all classes regarding the use of symbols and formalisms. At first sight, the tasks from the fourth class (n=143) seem to offer the highest potential for cognitive activation. On average, they have higher scores for both the use of representations and symbols and formalisms as well as far higher scores regarding the dimension of problem solving than tasks from all other classes.

As a next step in the analysis, the four classes of tasks will be further examined regarding other task characteristics. Thereafter, the ratio of tasks from each of the four classes will be examined for the different teachers and lessons. The ratios will then be correlated with other aspects concerning the teacher and the observed teaching quality throughout the course of the lesson. Preliminary results shall be presented and discussed at QUINT 2022.

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