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Open-ended tasks as approach for learning arithmetic in heterogeneous elementary classrooms

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Introduction

This study explores a teaching approach for heterogeneous learning groups in mathematics instruction. In elementary school the diversity of students is a key challenge. Since elementary schools draw their student body from residential areas, students exhibit a wide range of abilities and achievement levels. In order to cope with heterogeneous learning groups, various approaches have been developed within mathematics education. In the German context, these approaches base on the concept of differentiation through open-ended tasks that allow multiple solutions on different achievement levels. This concept is specifically labeled as ‘natural differentiation’ (literally translated) (Scherer, 2013). This concept assumes that students work on differentiating open-ended tasks according to their learning and performance level. Whether this assumption is also confirmed in practice has not yet been systematically empirically tested. This is the aim of the presented research project. The study will compare the individual learning condition of students and the performance level when working on an open-ended task that allows multiple solutions (naturally differentiation).

Theoretical framework

The theoretical framework is the offer/take-up model (Angebots-Nutzungs-Modell) (Göbel & Helmke, 2010) developed by Helmke. This model describes the complex processes of teaching and learning and all influencing factors in a simplified way. To explain the effects of teaching and learning success, the model gives a compact overview of the most important variable clusters.

In this project we offer students an open-ended task. Open-ended tasks allow multiple solutions at different levels and thus provide learning opportunities for students with different levels of proficiency. The use of open-ended tasks that allow multiple solutions on different achievement levels represents an innovative approach of teaching and learning arithmetic in heterogeneous classes and inclusive education (Lindenskov & Lindhardt, 2020).

Aim of the study

The study aims to determine to what extent the use of an open-ended task depends on prior knowledge and other variables of learning condition. Our research question is: Do students process the open-ended task "Kombi-Gleichungen" (invention of equations with multiple operations) according to their prior knowledge and individual learning conditions?

Methodology

The sample includes 160 third graders from different heterogeneous classrooms. Firstly, we assessed the learning condition of the students by a questionnaire to analyze students' attitudes towards learning mathematics and a standardized test to measure the achievement level in mathematics. The chosen instruments allow to survey cognitive learning prerequisites as well as motivational and volitional learning prerequisites. Secondly, we conducted two math lessons and offered all students the open-ended task to invent equations in which the equal sign is relationally used (e.g., $2 + 7 - 3 = 10 - 4$). This task allows multiple solutions, enables students to work at their individual performance level. The students' worksheets provide the database for our analysis. To assess the level of students' solution process, we use a category system (Friedrich & Rathgeb-Schnierer, 2020). Finally, we link level of the solution process to the learning prerequisites of the students.

Preliminary outcomes

After analyzing part of the data, it appears the highest processing level is characterized by invention of equations with different operations, multi-digit numbers, several calculation steps, and transitions with a systematic procedure. Inventing an equation system including two or even more complex equations is a characteristic of a high level of processing. All students were able to handle the open-ended task: Those who scored highly in the achievement test attempted to invent particularly complicated equations. Students with a low score invented many equations with few calculation steps.

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