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► **To cite this version:**

Mathias Norqvist, Johan Lithner, Bert Jonsson, Yvonne Liljekvist. Creative reasoning more beneficial for cognitively weaker students. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.502-503. hal-01286975

**HAL Id: hal-01286975**

**<https://hal.science/hal-01286975>**

Submitted on 11 Mar 2016

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# Creative reasoning more beneficial for cognitively weaker students

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In a study with 91 upper-secondary students the efficiency of two different types of mathematical practice tasks, procedural based algorithmic tasks and creative reasoning tasks, were studied. It was found that although the algorithmic group outperformed the creative group during practice the latter performed significantly better on a follow-up test. Closer inspection revealed that the difference in test performance was, contrary to common beliefs, driven by the cognitively weaker students.

**Keywords:** Mathematical reasoning, creative reasoning, cognitive proficiency.

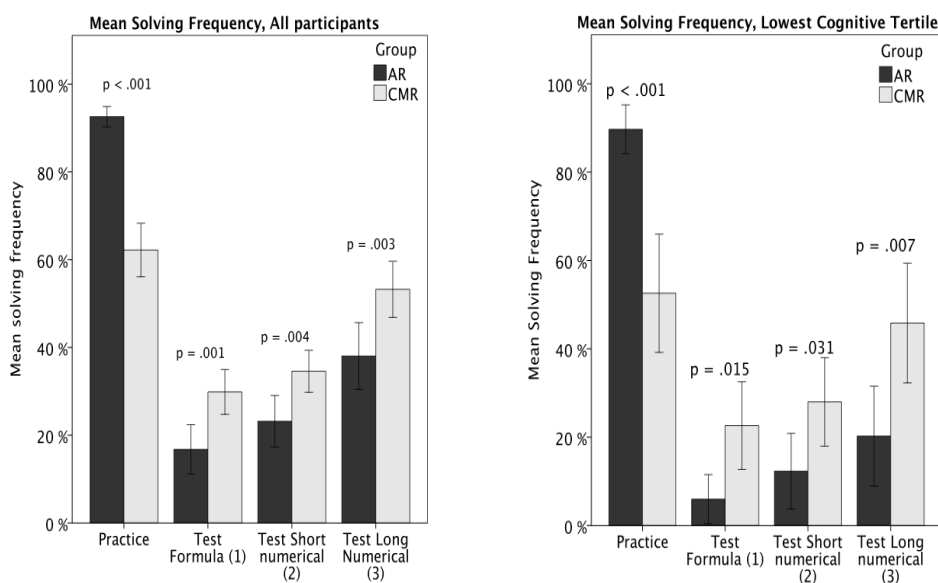
## LEARNING BY IMITATIVE AND CREATIVE REASONING

Starting off from research that points to the inefficiency of rote learning, the LICR design research project is studying the efficiency of different kinds

of practice tasks. One sort of task where the student is presented with an already complete solution or formula and has to practice this, much like the layout in most textbooks (Algorithmic Reasoning, AR). This is contrasted by a task type that gives no indication on how to solve the specific task, constructed in such a way that it gives the student a chance to, with small creative steps, construct a general solution (Creative Mathematically founded Reasoning, CMR). The tasks are designed based on the mathematical reasoning framework (Lithner, 2008) utilizing a specific didactical situation (Brousseau, 1997).

## METHOD

Our sample consisted of 131 students at the Natural Science program from four Swedish upper secondary schools (16–17 year olds) that after attrition and screening for ceiling effects was reduced to 91 (48 AR and 43 CMR). We used two cognitive tests, Raven's



**Figure 1:** The left diagram shows the mean result for practice and test for all participants while the right shows the mean result for the lowest cognitive tertile (error bars represent two standard error of means)

Progressive Matrices (non-verbal problem solving ability) and Operation Span (working memory capacity), to construct a cognitive composite score. Both of these tests have been proven to be of importance for mathematics achievement (Primi, Ferrão, & Almeida, 2010; Alloway, Gathercole, Kirkwood, & Elliot, 2009). The cognitive composite score, mathematics grade and gender were used to match the participants into two comparable practice groups, AR and CMR.

The two groups got to practice on 14 task sets, each with a specific target knowledge. The CMR-group solved three tasks per task set while the AR-group solved five tasks to compensate for the quicker AR-tasks. The allotted practice time was the same for both groups but there was a slight difference in used practice time, 29 min (SD, 10) for CMR and 21 min (SD, 6) for AR. One week later the two groups took the same test. The test consisted of three tasks per task set. They evaluated: 1) memorized knowledge of a specific formula, 2) if a mathematical principle was memorized, and 3) if the formula or principle could be reconstructed if forgotten.

## RESULT

Looking at the test result (Figure 1) the CMR-group significantly outperformed the AR-group,  $t(89) = 3.54$ ,  $p = .001$ ,  $d = 0.73$ , on all three tasks even though the AR-group performed much better during practice. The analysis also showed that the test performance of the AR-group was highly predicted by their cognitive score. The test performance of the CMR-group was predicted by their practice result and here a teacher can have huge impact. The most interesting result however is that the differences in test results were mainly driven by the cognitively weaker students rather than by the stronger students as might be expected according to common beliefs. Put together, these results would imply that CMR practice is more efficient with regard to remembered knowledge and also more neutral in terms of cognitive prerequisites (Jonsson, Norqvist, Liljekvist, & Lithner, 2014).

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