



UMEÅ UNIVERSITET

# FORMATIVE ASSESSMENT AND PROBLEM SOLVING IN MATHEMATICS

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## Akademisk avhandling

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## Abstract

In this thesis, the focus is on how reasoning in problem solving can be supported and which factors are associated with this support. In four studies, I investigated four aspects which address the overarching aim of the thesis. I report on two non-empirical studies and two intervention studies of formative assessment that deal with problem solving in mathematics.

Study 1 proposes a model based on different characteristics of feedback in mathematics education that have been studied in the literature. Study 2 addresses the effectiveness of different feedback types in mathematics. Study 3 investigates the usefulness of formative assessment in supporting students who engage in problem solving. Study 4 examines the relationship between a student's self-efficacy, national test grade, motivation type, learning goal orientation, task-solving success, and the perceived usefulness of feedback.

I have used the concept of devolution of problem from Brousseau's (1997) theory of didactical situations in mathematics to design a computer-based formative assessment support tool. The students were not provided with any solution method template to solve the tasks; instead, they were given the responsibility of constructing their own solution method with self-diagnosis and feedback support from the computer. The students determined where they had struggled and chose the diagnosis, and feedback was designed corresponding to each diagnosis. The feedback for each task starts at a relatively general metacognitive level; if it is insufficient, feedback is then provided in the form of general heuristic strategy suggestions.

Thematic analysis and systematic literature reviews were used in the first two studies. Participants in Intervention Study 3 were 17 first-year university students, whereas 134 students from upper secondary high school participated in Intervention Study 4. Think-aloud protocols have been used in this thesis analysis along with computer log files. In Study 4, structural equation model analyses were used.

The first study's proposed model identified in which ways the characteristics of feedback both between and within feedback levels may be very different and thereby might affect students' responses and learning differently. The results from Study 2 indicated that effective feedback provides to students sufficient motivational and cognitive support to use the feedback to engage in thinking about the mathematical learning targets. Such feedback characteristics are more often found in process-level feedback and self-regulation feedback than in task-level feedback. Study 3 showed how the use of computer-based formative assessment, including self-assessment and metacognitive and heuristic feedback, can support students to overcome difficulties in problem-solving by their own reasoning. The results from Study 4 showed that students' mastery goals had a direct effect on the perceived usefulness of the feedback, but no such effects were found for students' national test grades, self-efficacy beliefs, performance goals, intrinsic or extrinsic forms of motivation.

## Keywords

Formative assessment, problem solving, reasoning, computer-based assessment, feedback, types of motivation, self-efficacy.

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