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Responsive Pedagogy and Student Learning: Feedback practice and student learning in Mathematics

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Abstract
This paper share for discussion the framework, research design and some preliminary results of a large research project; "Responsive teaching and Student Learning in Mathematics" (RespMath). The project is contextualised in lower secondary school in Norway; 40 Norwegian 9th-grade classes (student age 14-15) in 10 schools and includes about 1000 students and 40 teachers. The project is quasi-experimental with a comparison group similar to the experiemental group (1000 students and 40 teachers). In the project, a comprehensive definition of student learning which includes achievements, self-regulation skills and confidence in the ability to learn, defined as self-efficacy, all of which relate to motivation for schooling. The main goal of the project is to examine the relationship between responsive pedagogy, defined as feedback practice, and students' learning in Mathematics, defined as achievements, self-regulation skills and self-efficacy. A pilot study for the student questionnaire was conducted in May 2016, involving 10 classes (n=198 pupils). Preliminary analysis of the data suggests that the way the teacher gives feedback to the learner has an emotional aspect by influencing degree of "fear of mathematics" (anxiety) to students (r=-.47, p<.01). This emotion linked to mathematics affects students' expectations related to their own coping (self-efficacy), (r=-.64, p<.01). The degree of self-assessed self-efficacy is closely connected to the emotion "joy of mathematics" (enjoyment), (r=.63, p<.01), and this emotion correlates positively with students' self-regulation (r=.57, p<.01). Preliminary analysis shows that teacher feedback effects students' self-efficacy beliefs, the effort students are willing to put into a task and the motivation to succeed.

Introduction

The aim of this paper is to share for discussion the framework, research design and some preliminary findings from a pilot study of the questionnaire of a large research project in lower secondary school in Norway. The project, named "Responsive Teaching and Student Learning in Mathematics" (RespMath) is funded by the Norwegian Research Council with a time frame from 2015-2018. The project has a quasi-experimental and intervention-oriented design and aims at developing innovative knowledge about teaching and learning mathematics. Data are collected from Spring 2016 until Spring 2017. The study is contextualised in 40 Norwegian 9th-grade classes (age 14-15) in 10 schools and includes about 1000 students and 40 teachers. There is a comparison group similar to the experiemental group (1000 students and 40 teachers).

The project aims at developing knowledge about how responsive teaching enacted in feedback practice can strengthen students' learning strategies and improve achievements by engaging in dialogues with the students to meet their emotional and cognitive needs. Moreover, we want to examine how an intervention may support teachers in developing the desired competence in feedback practices. Smith (2011) claims that teachers' assessment competence is crucial for improving student learning, and that the topic is not satisfactorily addressed in pre- and in-service teacher education. The RespMath project is thus a research and development (R&D) project. It combines teachers' professional learning, students' learning and rigorous research, all of which are crucial to move education forward by gaining more knowledge about the interplay and relationship between teaching and learning, between teachers' actions and students' implicit and explicit responses and actions.

The main goal of the RespMath project is to examine the relationship between responsive teaching, defined as feedback practice, and students' learning in Mathematics, defined as achievements, self-regulation skills and self-efficacy. Feedback is understood as a means to sensitively scaffold learning by supporting students seeking answers to three basic questions 'Where am I?', 'Where am I going?' and 'What shall I do next?' (Hattie & Timperley, 2007; Ramaprasad, 1983; Sadler 1989; 2010).

Acknowledging the importance of studying the impact of assessment on student achievements, we claim learning goes beyond improving content achievements. Students' belief in their own capacity to learn and their skills in regulating their own learning are crucial to developing independent learners learning for the future. This, we believe, is a major challenge for today's schools, and there is a need to develop new understandings of the relationship between responsive teaching and student learning. We believe responsive teaching can be understood as the recursive dialogue between the learner's internal feedback and external feedback provided by significant others and has defined this as *Responsive Pedagogy* (Smith, Gamlem, Sandal, & Engelsen, 2016). Responsive pedagogy centers around attending to, interpreting and responding to student thinking (Jaber & Hammer, 2016). The core of responsive pedagogy is the explicit intention of the teacher to make learners believe in their own competence and ability to successfully complete assignments and meet challenges, to strengthen students' self-efficacy, and to increase their overall self-concept. Thus the core of responsive pedagogy in this paper is the explicit intention of the teacher to provide feedback to support the learners' confidence to successfully complete assignments and meet challenges, to strengthen students' self-efficacy and self-regulation for learning (Smith et al., 2016).

Assessment and feedback are central topics in the Norwegian and international educational discussion, yet how teachers attend to and respond to student cognition and self-beliefs (Responsive Pedagogy) is a less known concept.

The overall research question for the RespMath project is: *What is the relation between responsive pedagogy (feedback practice) and student learning (achievements, self-efficacy and self-regulation)?* Sub-questions are: What are the differences between teachers' and students' perceptions of feedback practices? What is the effect of the intervention (working with teachers

on feedback practices over a period of 7 months) a) in terms of closing the gap between teachers' and students' perceptions of feedback? b) in terms of improving learning as defined above?

Timperley et al's (2009) model of teacher learning provides a theoretical foundation for the intervention with the teachers in the project. The starting point for teacher learning is the students' needs, and what teachers need to learn in order to help students learn. The next step is to support teachers in developing an understanding of the desired competence, in our case, math teachers' pedagogical feedback practices, in order to support teachers in translating understanding into practice, and to observe the impact of the changed practice on student learning.

Theoretical framework

The RespMath project is grounded in sociocultural perspectives on learning and assessment (Greeno, Collins, & Resnick, 1996; Vygotsky, 1986; Wertsch, 1991). We have, however, taken into account the critique raised against this perspective for not sufficiently including individual and cognitive aspects of learning (Hodkinson, Biesta, & James, 2008; Shepard, 2000). The study therefore draws on concepts from the socio-cognitive theory tradition which we consider useful when investigating such complex phenomena as learning and learning outcome, where individual and social aspects are closely interwoven.

Responsive pedagogy - feedback

Responsive pedagogy (Smith, et al., 2016) is an inherent component of teachers' assessment competence, and more specifically, the teachers' skills in using feedback as a pedagogical tool to foster student learning. It is also an integral part of formative assessment, in contrast to summative assessment (Darling-Hammond, 2010). The main purpose is not to judge student learning and set a grade, but to seek information about student learning which is fed back into the planning of teaching, as well as into the students' planning of future learning (Black & Wiliam, 1998, 2009; Sadler, 2010). However, feedback should relate to a wide perspective of learning. According to Winne and Butler (1994) "feedback is information with which the learner can confirm, add to, overwrite, tune, or restructure information in memory, whether that information is domain knowledge, meta-cognitive knowledge, beliefs about self and tasks, or cognitive tactics and strategies" (p. 5740).

Feedback can be formal in the form of written feedback on students' assignments; and it can be informal, integrated into the classroom interaction and taking place between teacher and students, students and teacher, and within peer groups. Informal feedback is found to be more useful to students than formal feedback (Black & Wiliam, 1998, 2009; Havnes, Smith, Dysthe, & Ludvigsen, 2011). This involves what Black & Wiliam (2009) call exploiting moments of contingency, points at which assessment and feedback practice becomes an integrated part of classroom interaction. Black and Wiliam's (2009) definition sums up the view of feedback taken in the current project:

> Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted and used by teachers, learners, or their peers, to make decisions about the next step in instruction that they are likely better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (p. 9).

Thus, one could say that both teacher and student are empowered by feedback that functions as a learning dialogue between the two, and they are both accountable for the interaction (Brown, 2008). Assessment and feedback practice needs to become an integrated part of classroom interaction (Black & Wiliam, 2009; Gamlem, 2015) to empower learning; assessment is learning (Hayward, 2015).

In the RespMath project, a comprehensive definition of student learning is used. It includes achievements, self-regulation skills (e.g. Pekrun et al. 2011; Pintrich, 2000; Zimmermann, 2000) and confidence in the ability to learn, defined as self-efficacy (e.g. Bandura, 1997; Schunk & Pajares, 2002), all of which relate to motivation for schooling (e.g. Ryan & Deci, 2000). Figure 1 illustrates how student learning is perceived in this project.

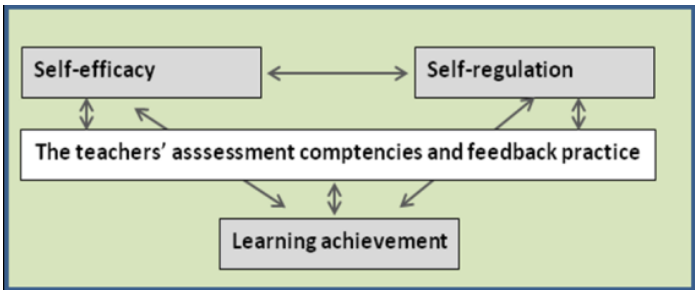

Figure 1: The perception of student learning used in the project, the approach to Responsive Pedagogy

Since the RespMath project aims to examine the effect of responsive pedagogy on students' learning in Mathematics in a wider perspective than achievements, students' self-efficacy and self-regulation are included as achievement goals. The project is situated within Bandura's (1997) theory of self-efficacy which implies that, in order to learn, students need to believe in their own competence to succeed. Self-efficacy is a strong predictor of motivation for learning, a condition for developing self-regulation skills and by making use of the autonomous learning space. In this project a central goal is to examine the effect of feedback practice on student learning of Mathematics in a wider perspective than achievements, including students' self-efficacy and self-regulation. The following discussion outlines how motivation, self-efficacy and self-regulation relate to feedback and student learning.

Motivation

Motivation is crucial to learning. Ryan and Deci (2000) conclude that extrinsic rewards (e.g. grades) are negative as they hinder students' from taking responsibility for their own learning.

Furthermore, they question whether extrinsic rewards should be regarded as feedback because this practice undermines intrinsic motivation, defined as a natural inclination to action based on spontaneous interest, free will, exploration and enjoyment (Ryan & Deci, 2000). Intrinsic motivation is related to the need for autonomy, competence and relatedness, and can be supported by feedback and a supportive social environment. Positive performance feedback can strengthen intrinsic motivation, while negative performance feedback tends to weaken it. Self-direction and the opportunity to choose among options can also strengthen intrinsic motivation, by enhancing the feeling of autonomy (Ryan & Deci, 2000). Intrinsic motivation needs supportive conditions if it is to develop and be sustainable. Independent choice, acknowledgement and self-direction support intrinsic motivation and the feeling of autonomy. Teachers who support students' autonomy can function as facilitators for increased intrinsic motivation (Vansteenkiste, 2011). According to Ryan and Deci (2000), a variety of different causes of action are associated with the concept extrinsic motivation, ranging from punishment and external rewards to personal choice and congruency with internal factors and beliefs. For feedback to enhance learning, however, it is necessary to make the value of the learning outcomes visible, and to relate them to students' values and interests (Ryan & Deci, 2000; Schunk & Pajares, 2002). The students need to develop a strong belief in their own ability to handle the learning tasks and to achieve the goals; they need to develop self-efficacy.

Self-efficacy

Self-efficacy refers to beliefs about one's ability to learn or perform behaviors at designated levels (Bandura, 1997). Self-efficacy influences motivation and cognition by enhancing interest in learning tasks, persistency, goal setting and use of cognitive and meta-cognitive strategies, as well as choices students make about the course of action.

The concept self-efficacy stems from the social cognitive perspectives of Bandura (1977) and his assumptions of human development and exercise of control of desired outcomes. "Perceived self-efficacy refers to beliefs in one`s capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is not related to personal traits, but to the individual`s efficacy belief to perform in a given situation (Bandura, 1997) or in school, self-efficacy is very much related to specific school subjects. Self-efficacy beliefs are domain specific, and they differ according to physical and social context (Zimmerman, 2000b; Bandura, 1997; Skaalvik & Skaalvik, 2004). Bandura (1993) underpins people`s beliefs in their own capacity to exercise control over their lives. These efficacy beliefs influence people`s thoughts, feelings, motivation and actions. Self-efficacy, therefor, is concerned with people`s beliefs about ability to organize and execute the courses of action needed to learn or perform behaviours at designated levels (Bandura, 1995). Human agency is grounded in the individual`s beliefs in efforts made to produce desired outcomes; individuals guide their lives by their beliefs in personal efficacy, or efficacy beliefs. In Bandura`s foundation of the self-efficacy concept he refers to three factors that inform how individuals interpret results of their performances; 1) personal factors such as cognition, 2) affect and biological events, and 3) behaviour and environmental influences. These three factors form a triadic reciprocity which

determines human agency (Pajares, 1996; Bandura, 1997). These factors do not have equal strength, and their influence will vary according to different activities and circumstances as well as socio-structural influences. For example, qualities of the relation between a teacher and the students will have an impact on the students` self-efficacy and their actions (Pajares, 1996). Self-efficacy has been found to correlate with achievement outcomes and with effective use of learning strategies (Bandura, 1997; Schunk & Pajares, 2002). Students' self- efficacy influences their persistence and the way they monitor their own learning process (Bouffard-Bouchard, Parent, & Larivee, 1991). Studies also show that feedback has an impact on self-efficacy, but not all feedback has positive effect. Feedback on task, rather than on person, strengthens students' motivation, goal process and self-efficacy (Schunk & Pajares, 2002). Boekaerts (2006) found that mastery-oriented students, who believe they have the competence to successfully carry out specific tasks, are independent and need less support.

To sum up, research indicates that feedback plays and important role in developing students' self-efficacy, although van Dinther, Dochy and Segers (2010) stress that more research is required, particularly focusing on younger learners since most of the research has been carried out in higher education. They also claim that it is important to examine student-teacher relations and combinations of instructional factors that influence students' meta-cognitive skills such as self-regulation.

Self-regulation

The literature suggests that self-regulation of learning is closely related to academic achievement (Andrade, 2010; Pekrun et al., 2011; Schunk & Zimmerman, 1997; Zimmerman, 2000), and that it is learnable (Andrade, 2010; Brown & Palincsar, 1982). Andrade (2010) state that self-regulation can be learned and improved by all learners. She defines self-regulation as exercising executive control over one's own learning, where self-regulated learning is understood as a dynamic process of striving to meet learning goals by generating, monitoring, and modifying one's own thoughts, feelings, actions, and, to some degree, context (p. 94). Self-regulation implies flexible goal-setting, planning, monitoring of progress and the ability to adapt learning strategies to task demands. Zimmerman (2002) argues that self-regulation is not a mental ability or an academic performance skill; rather it is the self-directive process by which learners transform their mental abilities into academic skills. Learning is viewed as an activity that students do for themselves in a proactive way rather than as a covert event that happens to them in reaction to teaching (p. 65). The learner is understood as the active agent for self-regulation by taking charge of the learning process instead of depending on the teacher and the teaching activities. Pintrich's (2000) definition of self-regulation aligns with Zimmerman's work , however points more specifically to the learners' own goal setting: "Self-regulated learning is the process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior in order to reach their goals" (Andrade, 2010, p. 91 referring to Pintrich, 2000). Further, Pintrich and Zusho (2002) give a slightly elaborated definition of the concept self-regulation, who provide the following working definition for the RespMath project:

> Self-regulated learning is an active constructive process whereby learners set goals for their learning and monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features of the environment (p. 64).

A number of key words deserve to be noted in the above definition, first that learners set the goals for their learning, and second that self-regulation does not only relate to the cognitive aspects of learning, but also to affective aspects such as motivation. Third, self-regulation takes place within a given context and learners are restrained by this context. There is strong research evidence showing that self-regulated learners do better in school than non-self-regulated learners (Andrade, 2010; Hattie & Timperley, 2007; Pintrich, 2000; Zimmerman & Schunk, 2004).

Research suggests that the flow of feedback on self-regulation seems to be problematic since much external feedback focuses on the task and the achievement of the goals of the task (Hattie & Timperley, 2007; Gamlem & Munthe 2014). Hattie and Timperley (2007) argue that feedback should not only be on the task, the goals and the outcome, but also on the process and the strategic choices learners make during the learning process. This aligns with Zimmerman's (2000) second phase of self-regulation, performance or volitional control, during which the learner monitors the learning process and if necessary, decides to make necessary changes. It is the learner who is the agent of this learning process, however useful feedback from the teacher or peer(s) if the learners accept it, is likely to enhance learning. Sadler (1989; 2010) in his work argues strongly for the need for learners not only to feel ownership of the task goals, but also to be fully informed about, understand, agree with, and being able to implement the criteria for assessing the outcome of the learning process (e.g. strategies used).

We believe that responsive pedagogy (Smith et al., 2016), if practiced with pedagogical wisdom and skills, can promote student learning, however, teacher feedback can also hamper student progress if it is perceived as negative and threatening by the learner. A question for the RespMath study is to what extent students and teachers have the competence to understand and act on the principles of responsive pedagogy, or do they need to engage in a learning process to understand its importance and translate the understanding into practical skills? Preliminary results from the pilot of the RespMath student questionnaire (n=198) will give some indications on the power of responsive pedagogy for enhanced learning.

Methods

The RespMath project has a quasi-experimental and intervention-oriented design and aims at developing innovative knowledge about teaching and learning mathematics. Data are collected from Spring 2016 until Spring 2017 using a pre-post test survey to examine the outcome of a 7 month long intervention with the teachers. To examine in depth what happens during the intervention within the experimental group, a qualitative approach is required, including video recordings from classroom lessons, and interviews with teachers, students and school leaders.

Students' achievement in mathematics is measured by using the national test for Mathematical skills.

The overall research question[1] and sub-questions 1 and 2[2] require a quantitative approach applying a contextualised questionnaire measuring feedback practice, self-regulation and self-efficacy.

The questionnaire used in the Respmath project is adapted from well-known and widely recognised instruments measuring self-regulation and self-assessment. These are: Motivated Strategies for Learning Questionnaire (MSLQ) by Pintrich, Smith, Garcia and McKeachie (1991), the 2003 version of the Cross Curricular Competencies (CCC) questionnaire validated for Mathematics in the Norwegian context trough the PISA project (Lie, Kjernsli, Roe & Turmo, 2001) and Pekrun's Achievement Emotions Questionnaire (AEQ) (Pekrun et al., 2011). The selection process of items of the RespMath questionnaire was conducted by first organizing each item from the selected surveys into a theoretical model of the concept Responsive Pedagogy. The RespMath research group was divided into teams for separate coding of the same items into the theoretical model. To ensure reliability of the coding an inter-rater reliability check was conducted after the first coding process. The agreement was above 80%. The RespMath questionnaire ended up with 85 items. Each item is checked for text comprehension by the use of LIX (Björnsson, 1968). The questionnaire has been piloted twice, first as a qualitative approach with observation of 9th grade students answering (n=10), followed by interviews with the informants afterwards. The second pilot was conducted by sending the questionnaire to a convenience sample of 240 students (9th graders) from the 10 experiment schools emphasizing factor- and reliability analysis, (n=198; 79% response). Total response rate for the pre-questionnaire for students is 90% (n=1795), (Experiment-group: n=1003; 94%, and Control-group: n=792; 85%). The achievement test in Mathematics will also follow a pre-and post according to the intervention study.

Structural Equation Modeling (SEM) allows us to test various theoretical models empirically (Schumacker & Lomax, 2010). Data (questionnaire and achievement test) from the level-three sample (n=1795), which includes measurements of students' perceptions of teachers' feedback practice, students' self-efficacy, self-regulation and achievement, are suitable to test theoretical models that hypothesize the relationship between those constructs through SEM analysis. The building of competence in the use of SEM is also a goal of this project.

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[1] *What is the relation between responsive pedagogy (feedback practice) and student learning (achievements, self-efficacy and self-regulation)?*

[2] *What are the differences between teachers' and students' perceptions of feedback practices? What is the effect of the intervention (working with teachers on feedback practices over a period of 7 months) a) in terms of closing the gap between teachers' and students' perceptions of feedback? b) in terms of improving learning as defined above?*

Results – preliminary analysis

For the overall research question for the RespMath project the hypothesis is that there is a positive relationship between responsive pedagogy (feedback practice) and student learning understood as achievements, self-efficacy and self-regulation.

Preliminary results from the pilot of the student questionnaire (n=198) coincide with our hypothesis (see Figure 2). In our pilot we find that the way the teacher gives feedback to the learner has an emotional aspect by influencing degree of "fear of mathematics" (anxiety) to students (r=-.47, p<.01). This emotion linked to mathematics affects students' expectations related to their own coping (self-efficacy), (r=-.64, p<.01). The degree of self-assessed self-efficacy is closely connected to the emotion "joy of mathematics" (enjoyment), (r=.63, p<.01) and this emotion correlates positively with students' self-regulation (r=.57, p<.01). Both self-regulation (r=.37, p<.01) and self-efficacy (r=.71, p<.01) correlate with the achieved grade in Mathematics. We argue that the feedback from teachers and peers effect students' self-efficacy beliefs, the effort they are willing to put into a task and the will to succeed.

Thus responsive pedagogy seems to be closely related to motivation for learning, it is through the learning dialogue teachers are positioned to strengthen, as well as weaken, students' self-efficacy beliefs. Based on results from the pilot study and theory, a model of how these constructs further relates to achievement (student learning) will be tested through Structural equation modeling (SEM).

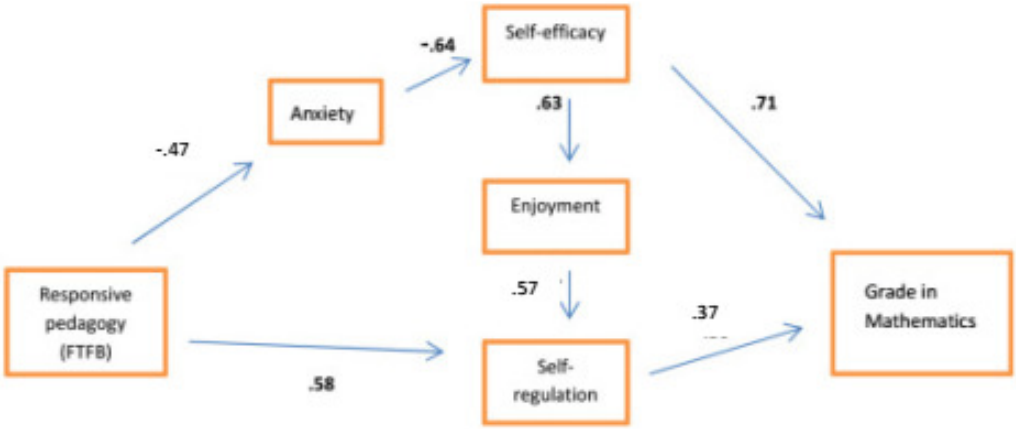

Figure 2: (Pearson r) – product-moment correlations between variables for responsive pedagogy (dimension: forthought feedback FTFB) and grade in Mathematics (n=198), note p<.01.

Further, the hypothesis for the 1st sub-question is that there are significant differences in teachers' and students' perceptions of feedback practices having a negative impact on the learning dialogue.

Scientific/scholarly significance of the study

The project aims at contributing with new scientific knowledge on the teaching of Mathematics and how to understand learning by examining in depth the relationship between teachers' responsive pedagogy, defined as feedback practice, and students' learning outcome in Mathematics, defined as achievements, self-regulation skills and self-efficacy. Schools and classrooms form social contexts, and feedback from teachers and peers effects students' self-efficay beliefs, the effort they are willing to put into a task and the will to succeed. Thus responsive pedagogy as understood in the current project is crucial to motivation for learning, it is through the learning dialogue teachers are positioned to strengthen, as well as weaken, students' beliefs in the possibilities for mastery. Responsive pedagogy (Smith, et al., 2016), if practiced with pedagogical wisdom and skills, can promote student learning, however, teacher feedback can also hamper student progress if it is perceived as negative and threatening by the learner. The question is the extent to which teachers practise responsive pedagogy that enhances student learning. With this project, we hope to contribute with new knowledge of how to act today to prepare for the future.

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