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Formative Scaffolding: how to alter the level and strength of self-efficacy and foster self-regulation in a mathematics test situation

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ABSTRACT

The aim of the present study is to advocate the use of a participatory action research programme, the Formative Scaffolding Programme (FSP), in mathematics. The FSP's main structure is presented as well as an implementation of a class intervention, with the aim of exploring the FSP test cycle's virtues in a social science class in a Swedish upper-secondary school. The motivations for the FSP's development were to enhance students' awareness of their mathematical proficiency, alter the level and strength of their self-efficacy, foster self-regulated learning (SRL), reduce and prevent mathematics-related anxiety, and visualise the learning process in mathematics. The primary findings of the study were there was a resemblance between the FSP setting and SRL phases, and that participation in the test cycle altered the level and strength of students' self-efficacy and fostered self-regulation in a mathematics test situation. The benefits of working in a formative scaffolding manner indicate that it is worth implementing the FSP on a larger scale. The study is an example of how students can engage in transforming classroom practice and be radical agents of change.

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Formative feedback; mathematics; scaffolding; self-efficacy; self-regulated learning; participatory action research

Introduction

Learning mathematics is an emotional practice generating a range of positive affective responses such as happiness, joy and satisfaction but also negative responses such as stress, hopelessness, fear and anxiety. Students' perceived experiences with mathematics will shape their beliefs about being able to do mathematics or not. Accordingly, negative emotions in relation to mathematics may result in mathematics-related anxiety and may consequently block cognitive processing when dealing with mathematics (e.g. Ashcraft 2002; Young, Wu, and Menon 2012). In addition, research suggests that, among other school-related factors, teachers represent the most decisive factor for student achievement as well as for the induction of mathematics-related anxiety (Hattie and Yates 2013; Maloney, Schaeffer, and Beilock 2013). However, 'the teacher cannot be the only expert in the classroom' (Delpit 1988, p.

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288). Therefore, to make a sensible use of learning we also need to listen to the students and give them influence in the world of education, because there is a need to ensure students become owners of their own learning (Hadfield and Haw 2001; Kane and Chimwayange 2014). Like pilots, who plan a course and take readings en route to ensure that the plane will land where it is planned to, we want students to develop their own learning strategies. Boaler (2002) found that students' knowledge development is 'constituted by the pedagogical practices in which students are engaged' (Boaler 2002, p. 43). By discussing and using mathematical ideas in another form than working through textbook exercises, students are presented with the possibility to deepen their mathematical learning, applying their mathematical practices in a variety of contexts and situations, thereby enhancing their awareness of the intricate relationship between knowledge and practice.

How students see themselves, their perceived self-concept (an individual's belief about him/herself) and self-efficacy (an individual's own assessment of his/her capacity in a specific context), and how students should be guided to develop their self-regulation (SRL) (an individual's ability to regulate and control his/her own thoughts, behaviour or emotions and change them depending on the situational and contextual demands) may have a powerful impact on how they interact, learn, engage and behave (McCarthey and Moje 2002; Wenger 1998).

Development of students' ability to self-regulate has been found to be one possible way to enhance students' proficiency and academic achievement (Pintrich 2004; Zimmerman 2002). Self-regulation should be viewed as a constructive and active process in which students set goals for their learning and then mobilise efforts and resources to reach these goals (Pintrich 2000; Zimmerman 2002). Motivational and affective factors have been shown to be important areas for SRL and for the development of students' SRL processes (Pintrich 2004). Consequently, the challenging question that teachers encounter in their daily work is how to design and implement instructional approaches that enhance low self-efficacy and develop the ability of self-regulation (Greathouse 2018). By engaging students in participatory action research (PAR) (Fals-Borda and Rahman 1991; McIntyre 2008; Townsend 2013), we see the student as someone whose opinion matters and, in addition, we provide a radical alternative to mainstream teaching strategies. Using PAR, the students are given the opportunity to be active participants in their own learning process and development of their proficiency in mathematics (Moreno and Rutledge 2018).

Comprehension of how affective factors impact on students' learning in mathematics is of importance for the understanding of how to empower students as learners, and the aim of the present study is to inform and contribute to the literature on these matters. Accordingly, we want to investigate if the use of PAR may empower students to transform classroom practice radically and as a result enhance students' self-efficacy and develop their SRL skills.

The present study has two parts. The first part is a general presentation of the development of a PAR programme, the Formative Scaffolding Programme (FSP) in mathematics. The second part presents, by applying a class intervention, an implementation of the FSP test cycle in mathematics and an evaluation of the FSP test cycle's virtues. Part two is an extension of part one.

Part one – the FSP

The work on the FSP began over a decade ago, as a response to students' communicated concerns regarding mathematics-related stress and anxiety. The dialogue with the students initiated a PAR cycle. The PAR cycle began with a discussion and planning stage (Kemmis, McTaggart, and Nixon 2013; Townsend 2013), which encompassed enhanced awareness of mathematical proficiency, visualisation of the learning process, and reduction and prevention of mathematics-related anxiety.

The goal of the PAR project was to engage students in transforming the mathematics classroom practice and become radical agents of change (Fielding 2001). Through the initiation of a PAR, the FSP was developed. This is a method for teaching, learning and assessing mathematics and considering tests in mathematics as a further opportunity for learning. The PAR cycle was evaluated recurrently and modified over the years with different classes in both lower- and upper-secondary school.

Theoretical background

Mathematics is a complex field encompassing many cognitive processes that require self-efficacy (Bandura 2012) and SRL (Black and Wiliam 2009). When referring to mathematical proficiency, the framework of five interwoven strands suggested by Kilpatrick, Swafford, and Findell (2001) is used. The five strands are, according to Kilpatrick, Swafford, and Findell (2001, p. 116):

- conceptual understanding – comprehension of mathematical concepts, operations and relations
- procedural fluency – skill in carrying out procedures flexibly, accurately, efficiently and appropriately
- strategic competence – ability to formulate, represent and solve mathematical problems
- adaptive reasoning – capacity for logical thought, reflection, explanation and justification
- productive disposition – habitual inclination to see mathematics as sensible, useful and worthwhile, coupled with a belief in diligence and one's own efficacy.

Fostering students' self-regulation and development of a strong sense of self-efficacy may help students to adopt these strands (Boaler 1999). SRL may increase the students' levels of self-efficacy beliefs, enhance their attitudes to the subject (productive disposition) and encourage their autonomy in learning mathematics.

Key features for improving students' academic performance and reducing or preventing any mathematics-related anxiety that stem from the PAR cycle are written feedback, formative feedback and assessment, scaffolding (when an expert guides a novice) and repeated opportunities to solve and work on given tasks. These features – the domains of scaffolding, formative feedback and assessment, and writing to learn – were merged into one single teaching, learning and assessment programme, the FSP.

Scaffolding

Scaffolding was originally introduced by Wood, Bruner, and Ross (1976) and referred to situations where an expert guides/tutors a novice. The expert has control over the elements of the task that the novice, the child, facing the elements has yet to master.

Holton and Clarke (2006) broadened the concept of scaffolding by adding the concept of self-scaffolding, suggesting that scaffolding also occurs within the individual and not solely between teacher and learner. Scaffolding should be viewed as 'a metaphorical bridge between the social and the personal' (Holton and Clarke 2006, p. 128), like an individual's voiceless thinking.

Scaffolding anticipates construction of some sort and supports immediate knowledge construction and extension of existing knowledge (e.g. Wood, Bruner, and Ross 1976). Combining scaffolding and formative feedback results in a powerful construct for enhancement of the individual's proficiency. (Hattie and Timperley 2007).

Formative feedback and assessment

Feedback and assessment must be a dialogue, a narrative that enhances students' understanding of what they know, what they can do and what needs further work. Effective feedback has four levels cooperating in a dynamic way to enhance learning: feedback about the task, feedback about the processing of the task, feedback about self-regulation and feedback about the self as a person (Hattie and Timperley 2007, p. 90). By using summative tests in a more formative manner, we activate students to be the owners of their own learning, resulting in a greater impact on students' learning, behaviour, interaction and engagement (Kågesten and Engelbrecht 2006; McCarthey and Moje 2002; Wenger 1998).

Writing to learn

Emig (1977) developed a powerful rationale for using writing in all disciplines, presenting writing as a unique mode of learning, as a way of presenting a person's voiceless thinking. Writing should be regarded as a tool for visualising mathematical processes and for supporting reasoning and problem-solving in mathematics.

According to Kågesten and Engelbrecht (2006), supplementary written explanations, subsequently provided to complement the answers in written examinations, force students to rethink their answers by attending to feedback given by the teacher; the students write in order to learn. Information about logical conclusions is thereby provided, which justifies the students' answers and, in that respect, explains their thinking and provides important information about the individual's current mathematical proficiency, and therefore constitutes an important basis for assessment. They found that students developed a deeper understanding and an enhanced awareness of their strengths and weaknesses regarding their knowledge of mathematical concepts when they were given the opportunity to provide supplementary written explanations. Writing becomes a self-reflective enquiry in action into doing mathematics.

If students are provided with a sense of control, they will be given the possibility and opportunity to alter their level and strength of self-efficacy and consequently will develop their self-regulation (Pintrich and Zusho 2002).

Self-efficacy

Self-efficacy is an individual's judgement of his or her capabilities to perform given actions and will affect an individual's choice of activities, effort and persistence (Bandura, 1977; Bandura 1986).

In the present study, self-efficacy is conceptualised as a predictor for students' motivation and learning strategies. It is implied that the learning process affects the expected outcomes and learning results. Self-efficacy is an important area for regulation in mathematics, and needs to coexist with formative feedback to enforce the metacognitive processes required for the acquisition of self-regulatory strategies (Pintrich 2004; Schmitz and Wiese 2006).

Self-regulated learning (SRL)

SRL is 'an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment' (Pintrich 2000, p. 453).

SRL is often conceptualised in the literature as a cyclical process of three or four phases and areas for self-regulation, with several sub-processes within each phase (e.g. Pintrich 2000; Schmitz and Wiese 2006; Zimmerman 2000, 2002).

The three phases, according to Zimmerman (2000, 2002), are as follows. First, the forethought phase, which concerns task analysis, such as goal-setting and strategic planning and self-motivation beliefs regarding areas such as self-efficacy, outcome expectations, learning goal orientation and intrinsic interest/value that precede the efforts to learn.

The second phase is the performance phase, which is divided into self-control and self-observation. Self-control refers to imagery, self-instruction, self-observation, and attention focusing and task strategies, while self-observation refers to self-recording and self-experimentation and concerns how to control and monitor emotions, behaviours and motivation. When the individual is actively making an effort to learn, the processes within the performance phase occur.

The third and final phase is the self-reflection phase and concerns processes that occur after the learning effort. There are two main classes of self-reflection: self-judgement and self-reaction. Self-judgement refers to the evaluation of oneself in relation to oneself and to others. Causal attribution is another kind of self-judgement and relates to one's beliefs about the causes of success and failure, for example, when taking a test in mathematics. Self-reaction can be either of a positive character, which increases self-satisfaction and enhances motivation, or of a negative character, which consequently leads to a decrease in self-satisfaction, undermining further efforts to learn, and which can lead to avoidance behaviour such as missing out on opportunities to learn and perform.

Schmitz and Wiese (2006) stress that Zimmerman's cyclical model for SRL only focuses on state aspects of self-regulation. Therefore, in their component model, they address the importance of situational influences and effects such as affective preconditions for learning, learning quality, learning quantity and learning outcomes. Even though much is known about SRL, it is emphasised in the literature that there is a need for curricular integration (Schunk 2005). It is also stressed that self-regulatory processes may vary depending on the context and subject, and that research is greatly needed on different content areas to advance knowledge about self-regulatory processes (Pintrich 2004; Schunk 2005). In part two of the present paper, a conceptual framework for self-regulation in mathematics is presented and used as an analytical tool.

Pintrich (2000, 2004) and Pintrich and Zusho (2002) develop these theories further and suggest a conceptual framework and a model of SRL comprising four phases and four possible areas of self-regulation. The first phase is forethought, planning and activation; the second phase is monitoring; the third phase is control; and the fourth and final phase is reaction and reflection. The four possible areas for self-regulation are cognition, motivation/affect, behaviour and context.

The emergence of the FSP in mathematics

The FSP

PAR should be understood as a self-reflective spiral with a planning phase, an action phase and a reflection phase, where research is used as a tool to detect and understand what you observe in order to bring change or an educational reform of some kind (Kemmis, McTaggart, and Nixon 2013; Townsend 2013).

The PAR cycle (see Figure 1) was repeated every year between 2000 and 2014, with over 560 students in lower-secondary education and over 480 students in upper-secondary education.

The key problems were identified: How can learning and tests in mathematics become less stressful, and how can mathematics-related anxiety be prevented or reduced? The students suggested that they wanted tests to be an extension of ordinary lessons; another opportunity for learning. The change was implemented, and the outcome of working with tests as an extension of ordinary lessons was evaluated. During the reflection phase, pros and cons were discussed and adjustments were made. The end result of the PAR process was the FSP.

The FSP is a process comprising two cycles which are closely integrated with each other: first, the teaching and learning cycle when using formative scaffolding in the mathematics classroom (Appendix 1), and second, the test cycle (Appendix 2), i.e. how to work in a formative scaffolding manner with tests in mathematics.

Writing to learn is an important feature in both cycles; students are given the opportunity to continuously work on given tasks and tests in order to visualise their learning of the mathematical processes and become aware of their true level of mathematical proficiency. It can be viewed as a self-reflective enquiry in action (McNiff 2014). Feedback on all levels is provided and individualised, and depends on the individual's level of mathematical proficiency and ability to self-regulate.

In the FSP, tests are regarded as additional opportunities for learning and not solely for assessment and grading. The aim is to empower students as learners. The test cycle begins when the students feel sufficiently prepared to test their knowledge, and discover their current level of mathematical proficiency and what must be developed to reach the next level. Here the scaffolding is a very important feature of the FSP. The students need guidance and support from the expert, the teacher, before they feel ready to begin the test cycle. The scaffolding and the feedback help the students to self-regulate their learning, and if needed, develop their self-regulation even further.

Thematic analysis (Boyatzis 1998; Braun and Clarke 2006) was applied to analyse the outcome of PAR. The analysis of the collected data from the PAR cycle (Figure 1) indicated resemblances between the FSP setting and SRL phases (e.g. Pintrich 2004; Schmitz and Wiese 2006; Zimmerman 2002).

The evaluation of the PAR process between the years 2000 and 2014 demonstrated that the overarching merits of using the PAR-developed FSP were that the students' level and strength of self-efficacy were altered. The students' SRL processes were developed, and students' awareness of their mathematical proficiency levels was enhanced while mathematics-related stress and anxiety were reduced. The resemblance found between the FSP and SRL phases resulted in adapting the model of SRL and areas for self-regulation to focus on mathematics. The evaluation process showed that the merits of the FSP were in line with the previous research stating that the development of students' ability to self-regulate enhances proficiency and academic achievement. Hereby, it was decided to move in new directions (Figure 1) and to investigate what would happen if the FSP was implemented among students that had not participated in

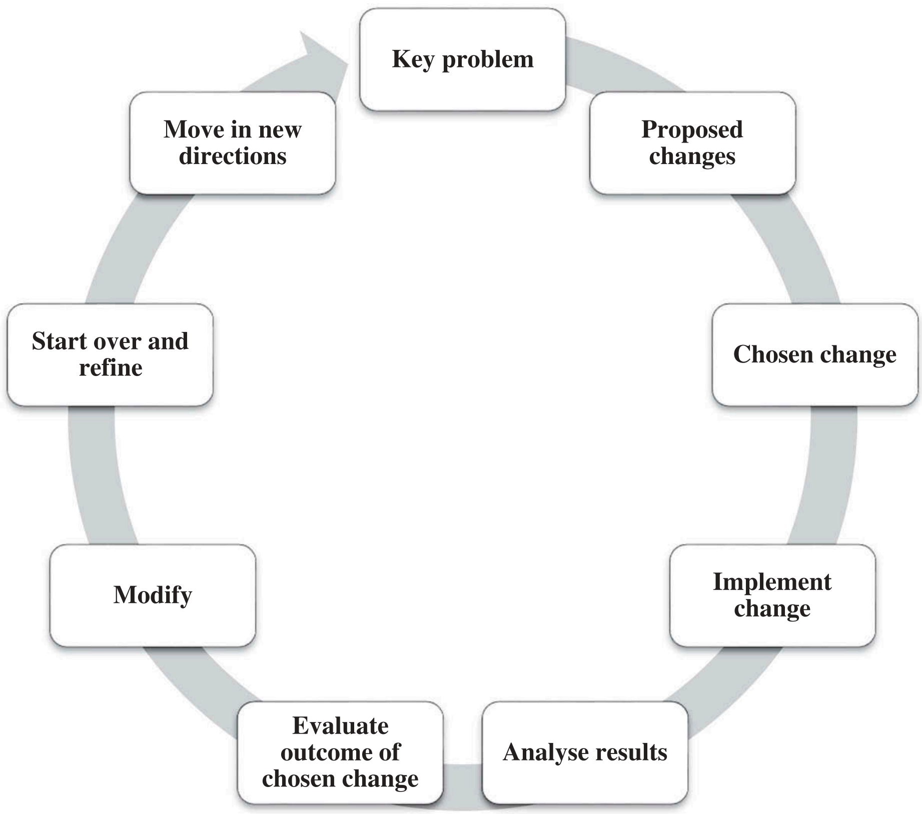

Figure 1. Participatory action research process behind the emergence of the FSP.

the development of the FSP. In addition, it was also decided to explore if the FSP would be worth implementing at a wider scale in a future perspective. In particular, we wanted to explore whether the application of the FSP could transform teaching practices and whether students have the ability to transform classroom practice and be radical agents of change. With tests in mathematics being a natural part of mathematics courses, we decided to adopt the students' suggestions of letting the tests become an extension of ordinary lessons. This resulted in the decision to investigate the effects of the implementation of the FSP test cycle, which is presented in part two.

Part two – implementation of the FSP test cycle

The purpose of part two is to explore the merits of the FSP by implementing the FSP with students who have not participated in the emergence of the FSP and to investigate whether it is worth implementing the FSP on a wider scale to transform mathematics-teaching practices and contribute to school development in general. A methodological proposal of a class intervention to implement the FSP test cycle in mathematics (Appendix 2) was designed. In addition, a conceptual framework for self-regulation in mathematics is presented and used as an analytical tool. For theoretical background and information on the FSP see part one.

The aim of the implementation of the FSP test cycle was to investigate the following research questions:

- What phases, areas for regulation and sub-processes of SRL in mathematics can be found when implementing the FSP test cycle?
- If any phases, areas for regulation and sub-processes in mathematics are found, what impact could these then have on the students' mathematics-related anxiety and awareness of their mathematical proficiency?
- Does the FSP alter the level and strength of self-efficacy?

Context and participants

The study participants were 22 upper-secondary social science students (11 males and 11 females), 17 and 18 years of age. The upper-secondary school was situated in central Sweden. Upper-secondary school education in Sweden is voluntary and free of charge.

The social science programme is one of 18 national upper-secondary programmes in the Swedish school system. Participation was entirely voluntary.

Data collection

The empirical material consisted of written narratives in which the students were asked to communicate their experiences, understandings and onions on the virtues of the FSP test cycle. Before the students began the test cycle, they were asked to indicate on a five-point Likert type scale how worried they felt when entering the FSP test cycle and taking the mathematics test. The Likert scale had five categories of response, from 1 = 'Not at all' to 5 = 'Very much'. The students were also asked to write about their feelings, understandings and expectations about the situation before they began the test cycle. After they had experienced the test cycle, they were once again asked to write about their perceived experiences and understandings about the test cycle and its pros and cons. Field notes on informal conversations were taken to improve the accuracy of the analysis process.

Data analysis

The students' written narratives were analysed using thematic analysis and a conceptual model for self-regulation in mathematics (e.g. Boyatzis 1998; Hayes 2000) with the aim of detecting phases, areas and sub-processes of SRL (Table 1). The thematic analysis was used to identify recurrent patterns and themes in the data in order to find commonalities.

Illustrative quotes were chosen to illustrate and describe the students' experiences and understandings of the FSP test cycle. The students' quotes were coded according to which student in the data material they were referring to and their recorded score on the Likert scale. For example: student number 8 who recorded '3' on the Likert scale had the following code: (S8, L3).

Informal discussions with the participating students, regarding their written reflections of their experiences, were held to ensure the correct interpretation of their intended meanings.

A model of SRL and areas for self-regulation in mathematics

Zimmerman's (2000, 2002), Schmitz and Wiese (2006) and Pintrich's (2004) component models and conceptual framework of SRL form the theoretical background for our suggested model for coding and detecting SRL processes, areas, and sub-processes in mathematics. The model (Figure 2) is an adaptation of Zimmerman's cyclical phase model of SRL (Zimmerman 2000, 2002), Schmitz and Wiese (2006) suggested the component model of SRL and Pintrich's (2004) conceptual framework of phases and areas for self-regulation.

SRL is often generalised across contexts, and there is a need in the literature to gain a deeper understanding about SRL processes in different content areas. Hence, SRL processes, sub-processes and areas for self-regulation may differ depending on the content area (Schunk 2005).

The phases, areas and sub-processes for self-regulation in mathematics applied in the current study are presented in Table 1.

Results

Analysis of the students' experiences and understandings before and after participation in the FSP test cycle concerning the implementation of the FSP test cycle, revealed that the most prominent phases of SRL were the 'Pre-action' phase and the 'Post-action' phase and that the prominent areas of regulation during both phases were cognition, self-efficacy, motivation, affect/emotion, behaviour and context/situation. In Table 2, the results are presented of the students' self-assessment of how worried they felt before entering the FSP test cycle.

Table 1. Phases, areas and sub-processes for self-regulated learning in mathematics

	Areas for regulation in mathematics					
Phases	Cognition	Self-efficacy	Motivation	Affect/emotions	Behaviour	Context/situation
Pre-action, forethought and planning	Goal setting in relation to the task	Efficacy-judgments	Intrinsic – for inherent satisfaction	Mathematics anxiety Test anxiety	Avoidance Persistence	Perceptions of task
	Valuation of one's mathematical proficiency	Outcome expectations	Extrinsic – want to attain some separable outcome	Anxiousness Stress	Time and effort planning for task/learning period	Perceptions of context
	Metacognitive knowledge activation			Enjoyment Hope Pride Anger Boredom Hopelessness		Perception of situational demands
Action, performance, monitoring and control phase	Learning strategies	Resource strategies Self-experimentation	Usage of strategies for attention and motivation control	Select stategies for managing affect and emotions	Increase/ decrease effort	Monitoring and controlling task
	Usage and awareness of one's mathematical proficiency	Self-observation		Affective and emotional reactions during performance	Help-seeking	Alteration of task
	Metacognitive awareness				Coping with distractions	Monitoring changing task and context conditions
	Monitoring and controlling of cognitive strategies Selection and adaptation of strategies for learning, thinking					
Post-action, reaction and self-reflection	Evaluation	Self-judgement	Attributions	Attributions	Evaluation if time invested in task/learning period was used effectively	Evaluation of task, context, situational demands and the impact the evaluation has on learning process and outcome
	Cognitive judgements Attributions	Evaluation of outcome Learning process and learning results impact on self-efficacy		Affective and emotional reactions Positive Negative	Coping with outcome	

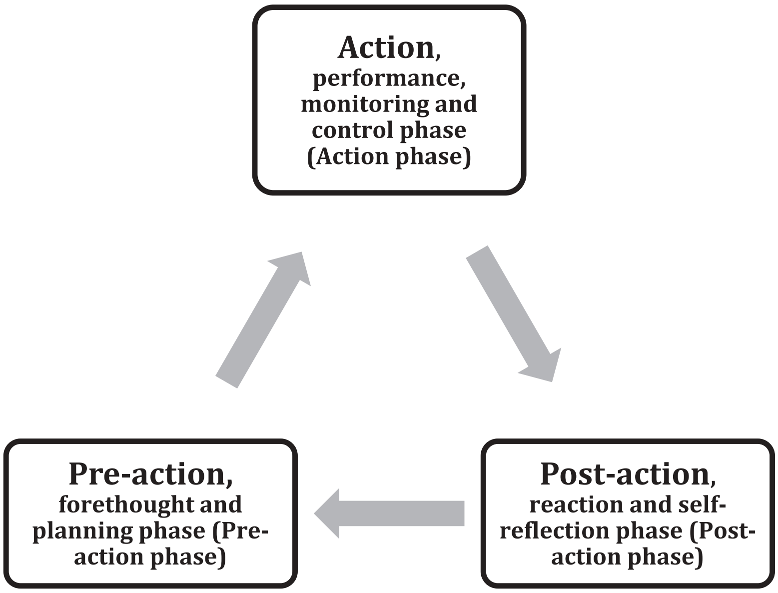

Figure 2. Phases of self-regulation in the present study.

Table 2. Students' results of their self-assessment of how worried they felt before entering the FSP test cycle.

Likert scale	Not at all (1)	Slightly (2)	A fair amount (3)	Much (4)	Very much (5)
Students	0	7	4	3	8

Pre-action phase

All areas for regulation in mathematics were found in the Pre-action phase (Table 1).

Cognition

Before beginning the test cycle, the students evaluated their mathematical proficiency. This evaluation seemed to preoccupy their minds to such an extent that 'goal-setting in relation' (Table1) to the task did not even exist.

> *I am worried about being assessed because I am uncertain of my proficiency in mathematics and how you perform in tests is the only thing that the teachers assess (S1, L2).*

The students' previous experiences were that assessment of their mathematical proficiency was determined only by how they performed in tests. They emphasised that there could be a risk that their true proficiency would not be seen, leading to an inaccurate assessment, by the teacher and by the individuals themselves, of the individuals' level of proficiency. A cognitive uncertainty in connection with their mathematical proficiency, which results in a low level of self-efficacy and feelings of uncertainty when it comes to outcome expectations, tended to be experienced by students who had not worked in an FSP manner before. However, the students experienced an uncertainty regarding the new situation with their participation in the FSP test cycle because they wanted to perform at the same level as they previously did.

> *I want to perform at the same level as I did last time, and not lower my performance level (S20, L2).*

Mathematics encompasses many demanding cognitive processes, which may be blocked due, for example, to stress and anxiety about the test situation, in students who struggle with mathematics.

> *I worry that I have not learned anything. I think mathematics is really hard, and when it is difficult, then I turn off my brain (S11, L5).*

Students like (S11, L5) with a high level of mathematics anxiety indicated a tendency to evaluate their proficiency in a negative sense. They associated themselves with a low level of proficiency in mathematics.

Self-efficacy

The students' efficacy judgements and outcome expectations are important sub-processes of the Pre-action phase, because a high level and strength of self-efficacy are required for an individual to be able to self-regulate. However, instead of trusting in their mathematical proficiency the students expressed concern that they would fail in the mathematics test, and that their poor performance would affect their grades and furthermore their future career endeavours in a negative sense.

> *I am worried because I am going to fail and be assigned the grade IG (fail) and thus not get my upper-secondary school diploma, which will affect my future (S11, L5).*

> *I worry about my grades and how they will affect my future life (S3, L4).*

It may be concluded that during the Pre-action phase, students' outcome expectations were focused on performance and not how to enhance their mathematical proficiency and mathematical understanding. It is reasonable to assume that this indicates low ability in SRL.

Motivation

Analysis of the students' pretest cycle narratives revealed the presence of only extrinsic motivation.

> *You only study to pass the tests in mathematics then you forget what you've learned and can't use it the next time you are faced with a similar problem. How you perform in tests is the only thing that counts when the teachers evaluate your achievement in mathematics (field notes).*

> *I am a little worried about what I will be able to achieve because I want to perform as well as possible in the test in order to get a good assessment (S18, L2).*

This was a clear indication that students' common perception of mathematics tests, and its associated assessment, is solely based on their performance on tests and not their proficiency.

Affect/emotion

It may be reasonable to assume that individuals with lower levels of mathematics-related stress and anxiety show a tendency for anxiety only related to tests in mathematics.

> *I am feeling rather worried because I always become nervous when there is a test in mathematics. I worry about the tests (S13, L3).*

I am always nervous before a test in mathematics because a test in mathematics always causes anxiety (S22, L2).

Individuals with high levels of mathematics-related anxiety (L5) did not express any anxiety related to the test situation; instead, they expressed anxiety directly related to their proficiency.

I have difficulties with mathematics, and I am really anxious because I have not mastered maths (S5, L5).

A reasonable assumption for this pattern is that mathematics anxiety was already present, and the underlying cause was the individual's efficacy judgements and perception of their mathematical proficiency.

Students exhibiting high levels of mathematics anxiety showed a tendency to have predetermined conceptions of their mathematical proficiency and tended to avoid monitoring and controlling of their cognitive strategies.

Behaviour

One aspect of self-regulation involves individuals' ability to control their own behaviour. Students need to be able to allocate time and effort to plan and make strategies for their learning. However, it seems that mathematics-related stress and anxiety may have affected their ability to make the right strategic decisions.

I find mathematics difficult, so I haven't prioritised mathematics as a subject (S5, L5).

In general, students' self-evaluation of their mathematical proficiency, which was based on their efficacy judgements and outcome expectations, determined whether they would exhibit avoidance or persistence behaviour in mathematics-related tasks.

Context/situation

There are certain situational demands, tasks and contexts that are not always under the direct control of the learner. The findings indicated that the FSP's test cycle, which, for the participating students, was a completely new way of taking tests in mathematics, showed a tendency to create uncertainty within them.

I am unaccustomed to doing a test in mathematics in this manner. I do not know what it will be like or what the outcome of my performance will be (S22, L2).

I am worried because I have not had the opportunity to prepare for the test during the past few days (S10, L4).

Certain situational demands, which often do not have a direct connection to school, tended to have a negative impact on students' behaviour.

I've had a busy week in which study has been impossible, so I have not had the opportunity to prepare myself as I wished (S18, L2).

The students experienced a lack of control that gave rise to concerns and anxiety about the mathematics test. Due to the fact that the FSP test cycle was a new experience, the student had even less control over the situation.

Post-action, reaction and self-reflection

The findings showed that all areas for regulation in mathematics were activated during the Post-action phase.

A prominent feature of the students' participation in the test cycle was the students' enhanced awareness of their mathematical proficiency.

Cognition

The students made cognitive judgements and in general, they emphasised increased awareness of their mathematical proficiency. The possibility of redoing already solved or unsolved tasks in the given mathematics test a second time appeared to be an important feature of the FSP test cycle and also seemed to be a key factor in helping students to increase their awareness of their mathematical proficiency.

> *You are given the opportunity to show what you have really mastered in mathematics. My perception of my proficiency in mathematics has become clearer because I managed to solve several tasks the second time that I did not manage to solve during my first attempt (S11, L5).*

The cognitive judgements students made indicated that they changed their perception of their ability in problem-solving and thereby re-evaluated their level of mathematical proficiency when they were given the opportunity to redo tasks.

> *I think it was a very good way to show my mathematical proficiency, especially because it took away the ordinary stress and pressure that surrounds a test in mathematics. I felt more relaxed, calm and at ease when I took this test, which resulted in better achievement and performance. It changed my view of how I think and how I perceive a test in mathematics (S1, L2).*

Students were given a sense of control, which led to a positive impact on their performance and reduced their mathematics-related stress and anxiety. Students changed their attitude and motivation regarding the test in mathematics, and an inner drive to solve the tasks was registered. The students changed from being extrinsically motivated to intrinsically motivated.

Self-efficacy

The FSP's learning process with the opportunity to supplement their answers and redo solved or unsolved tasks had a positive impact on the students' self-efficacy. The students expressed a change in attitude towards mathematics tests.

> *I felt more relaxed, calm and at ease when I took this test, which resulted in better achievement and performance. It changed my view of how I think and how I perceive a test in mathematics (S1, L2).*

> *It was good that you were given the opportunity to supplement your answers. You learned more and you were given the opportunity to show in a better way that you had mastered the different parts. You were given a second chance to prove that you could do some stuff, and that you had just had a 'meltdown' the first time (S13, L3).*

Through the given opportunity to redo tasks, students revisited the Pre-action phase and were given the possibility to renew their efficacy judgements and alter their outcome expectations, as well as reduce any stress and anxiety related to the test.

Motivation

The students moved from being extrinsically motivated to being intrinsically motivated. During the Pre-action phase, it became clear that the students' common perception was that the assessment of their ability in mathematics was based solely on how they performed in the given mathematics tests. They were unaware of their true mathematical proficiency and did not discuss any strategies for learning mathematics at all.

> *You only study to pass the tests in mathematics, then you forget what you've learned and can't use it the next time you are faced with a similar problem. How you perform in tests is the only thing that counts when the teachers evaluate your achievement in mathematics (field notes).*

After the students had worked according to the FSP's test cycle, they expressed an increased awareness of their own abilities and level of mathematical proficiency. In addition, they showed more interest in the task at hand.

In the Pre-action phase, one student expressed some worries:

> *I am a little worried about what I will be able to achieve because I want to perform as well as possible in the test in order to get a good assessment (S18, L2).*

The same student reflected on the test cycle in the Post-action phase:

> *The negative thing is that it takes longer and steals time from work on the textbook. But you learn more for life, so it depends on what is best (S18, L2).*

According to observations made before the implementation of the FSP test cycle, the class was in general rather unmotivated to do anything during ordinary mathematics lessons. The students often focused on things other than solving the mathematics problems presented to them. They often talked about things related to their life outside school and walked in and out of the classroom. The following reflection was made after the class was given the opportunity to supplement their answers, indicating an enhanced focus on the task ahead.

> *I'm stunned and surprised at how quiet our class is. Everyone is working, I don't believe that has happened before (field notes).*

The students emphasised that they were given the opportunity to understand what they had done wrong. They were thereby provided with a sense of control that made them more intrinsically motivated, and more willing to invest interest.

> *You are given the opportunity to understand what you know and do not know and are given the opportunity to fix things and learn to understand. I just love this way of working with mathematics (S1, L2).*

During the Pre-action phase, the same student had said: 'I do not trust my skills in mathematics'.

After implementation of the test cycle, the students were more intrinsically motivated and aware of their own abilities and more motivated to learn mathematics and complete the task at hand. The students expressed enjoyment and hope instead of worrying about failure.

Affect/emotions

The types of anxiety that the students stated they experienced during the Pre-action phase were: mathematics anxiety, test anxiety and anxiety about being evaluated and assessed on their performance and ability in mathematics. The students said that in the Post-action phase they experienced that their mathematics-related anxiety had been reduced.

> *It was a good way of working with a test in mathematics. I liked that you were given the opportunity to process the test again and had the chance to alter your performance. The opportunity to supplement your answers makes it less stressful. However, I still think mathematics is difficult (S14, L5).*

> *This way of working with tests in mathematics reduces anxiety because you know that it is not all hanging on this particular test on this particular day. It is just brilliant that you have the opportunity to supplement your answers. You are given the opportunity to understand what you know and do not know and are given the opportunity to fix things and learn to understand. I just love this way of working with mathematics. As I said, it reduced my anxiety because it took away the pressure (S1, L2).*

They sensed that they were given control over their own learning process because they were given the opportunity to supplement their answers.

> *I'm always nervous before a mathematics test. That's because it's all about mathematics and because it's a test in mathematics. However, the possibility of supplementing your answers and showing that you can actually solve mathematical problems reduces your stress (S21, L2).*

> *You are given the opportunity to show what in particular you need more help with. The view of one's proficiency in mathematics becomes clearer. Anxiety is reduced because the test becomes more about just ordinary tasks to work on, but you engage more with them. The test is not like a test anymore, so the anxiety about mathematics and about the test situation as such, as well as the anxiety about not performing well, are reduced (S5, L5).*

It is reasonable to assume that the function of visualising the individual's learning process within the FSP leads to an altered level and strength of self-efficacy, and an improved SRL in mathematics, and results in reduced mathematics-related anxiety.

Behaviour

The students' evaluation of the time invested in participation in the FSP cycle was positive and showed that the results were handled in a positive manner, with positive effects on behaviour. However, some negative thoughts about the FSP test cycle were expressed.

> *You were given the opportunity to study more and learn everything better. The negative thing is that it takes longer and steals time from work in the textbook. But you learn more for life, so it depends on what is best (S18, L2).*

It is worth investing more time if the results show that it is worth it and in the long run it may be shown to be time-saving.

Context/situation

During the Post-action phase, students evaluated the task they had been given. They also evaluated the context and possible situational demands and what kind of impact these factors had had on the learning process as well as the outcome. The possibility to redo tasks made the students re-evaluate their perceptions of task and context, resulting in a type of cognitive evaluation in which the students re-evaluate their mathematical proficiency and its impact on their performance.

> *You do not see the test as a real test of mathematics, so to speak. It is rather like evidence of what you know and what you do not know in mathematics (S18, L2).*

> *Anxiety is reduced because the test becomes more about just ordinary tasks to work on, but you engage more with them. The test is not like a test anymore (S5, L5).*

Analysis of the Post-action phase showed that the students' perceptions of a mathematics test changed and mathematics-related anxiety was reduced. The students moved their focus from being worried about the test and outcome to learning and understanding mathematics, leading to a positive effect on students' self-efficacy and SRL.

Finally

To conclude, the positive impact that formative scaffolding provided for both students and teachers was emphasised. Accordingly, the FSP provided the teacher with the information needed to assist students in bridging the gap between their current performance level and the desired goal. When the FSP test cycle is utilised, it resulted in a learning environment in which development of self-efficacy, self-regulation and areas for regulation in mathematics was made possible.

Discussion and implications

The findings from the PAR-developed FSP showed a resemblance between the FSP settings and the SRL phases, with areas for regulation and sub-processes included (Pintrich 2004). The outcome of the evaluation of the PAR cycle indicated that participation in the test cycle altered the level and strength of the students' self-efficacy and fostered the students' self-regulation in a test situation with respect to mathematics. It was found that the students, when they are given the opportunity to be radical agents of change (Fielding 2001), tried to change the classroom practice in the direction of SRL. Their knowledge development was influenced by their engagement in the pedagogical practice they participated in Boaler (2002).

The FSP test cycle was divided into three phases: pretest, doing the test, and a posttest equivalent to the SRL's Pre-action phase, the Action phase and the Post-action phase (Schmitz and Wiese 2006).

The findings from part two showed that all areas for regulation were present in the Pre-action phase as well as in the Post-action phase.

In the Pre-action phase, the students stated that they questioned their mathematical proficiency, while in the Post-action phase they emphasised enhanced awareness of their mathematical proficiency. It is reasonable to assume that formative scaffolding tends to visualise the individual's learning process and provides a representation of the individual's level of mathematical proficiency. It may be concluded that the opportunities to supplement answers and show one's true mathematical proficiency functioned as a feed-forward process, with a powerful impact on learning proficiency (Hattie and Timperley 2007) and enhanced the awareness of the intricate relationship between knowledge and practice (Boaler 2002). Students moved from being extrinsically motivated to being intrinsically motivated and tended to attribute success to internal factors instead of external ones (Hattie and Timperley 2007).

In the Post-action phase, the students re-evaluated their level of mathematical proficiency parallel with their evaluation of the outcome. Awareness of their mathematical proficiency was enhanced through the opportunity to supplement answers and rethink solutions in the given mathematics test. The visualisation of the learning process provided the students with a sense of control.

The possibility to 'redo' the Pre-action phase when given the opportunity to supplement answers and rethink solutions made the students invest more time and effort and re-evaluate their mathematical proficiency. In addition, their outcome expectations were altered, with a positive impact on the students' self-efficacy and areas for regulation in mathematics.

The students evaluated their learning outcome and self-assessed what they had accomplished, and accordingly altered the level and strength of their self-efficacy and ability to self-regulate (Pintrich 2004; Schmitz and Wiese 2006; Williams 2010). The motivation was driven from the inner self, which resulted in an enhanced awareness of one's mathematical abilities. The students became, according to their narratives, more motivated to learn mathematics and to complete the task at hand, indicating that the FSP test cycle tended to have a positive impact on students' behaviour (Pintrich 2004). The findings indicated that feedback given in a formative scaffolding manner tends to help less effective learners to become more effective ones. The opportunity to supplement one's answers encouraged the students to willingly invest more effort and persist with the task at hand (Hattie and Timperley 2007).

In the Pre-action phase, students said that mathematics-related stress and anxiety were present in that they perceived that assessment and grading were based only on their performance in a given mathematics test. This, in turn, hampered the cognitive processing when dealing with mathematics and could evoke mathematics-related anxiety. The grades became an obstacle to learning (Boud 2000). This resonates with the current literature highlighting these questions and emphasising that assessment and feedback must provide opportunities for learning as well as strategies for the improvement of learning, and not just non-useful data (Boud and Molloy 2013).

Individuals with mathematics anxiety show a tendency to associate themselves with low levels of proficiency in mathematics, leading to low efficacy judgements. These low levels of self-efficacy will in turn affect student performance. The low level of self-efficacy, the perception of not having the capacity to master mathematics, and perceiving mathematics to be a troublesome and difficult subject will, in combination, evoke mathematics-related anxiety. Mathematics-related anxiety has a tendency to lead to avoidance behaviour (Ashcraft 2002).

In other words, individuals with mathematics-related anxiety associate themselves with a low level of proficiency in mathematics and low efficacy judgements, and have low outcome expectations and worries about how their future will be affected. These findings are in line with the extensive literature on the effects and consequences of mathematics-related anxiety (e.g. Ashcraft 2002; Young, Wu, and Menon 2012). Mathematics anxiety is known to hamper cognitive processing. It is reasonable to assume that if individuals are given the opportunity to alter their evaluation of their mathematical proficiency, as in the FSP, the cognitive processes could become unblocked, the metacognitive knowledge could become activated and the level and strength of self-efficacy could be altered. The level and strength of self-efficacy are important factors affecting the reduction and prevention of mathematics-related anxiety (Black and Wiliam 2009; Butler and Winne 1995).

Accordingly, it is reasonable to conclude that the FSP test cycle provides the opportunity to alter the level and strength of self-efficacy.

An important feature of the test cycle that was detected was the possibility to visualise, for the individual, the true picture of their mathematical proficiency by providing scaffolding at the right level, thereby being able to assess the individual's knowledge properly in order to rate the student correctly. The students, engaged as participatory researchers, emphasised the positive impact that the use of the FSP had for both students and teachers in mathematics.

To equip students with a sense of control is an important feature of well-functioning formative feedback and is in line with existing literature within the formative feedback domain (Hattie and Timperley 2007). A sense of control improves an individual's self-confidence, which alters the level and strength of self-efficacy beliefs and improves self-regulation (Hattie and Timperley 2007). It is, therefore, reasonable to argue that the formative feedback, provided within the FSP test cycle, equips students, together with the visualisation of the students' level of proficiency and alteration of the level and strength of their self-efficacy and areas for self-regulation, with a sense of control. Consequently, these constitute the key factors for providing control. (Pintrich and Zusho 2002).

Through writing, students can provide important information about logical conclusions that are made and accordingly justify decisions regarding the solutions to a given problem, and explain their thinking (Kågesten and Engelbrecht 2006). Consequently, the possibility given in the FSP's test cycle to supplement answers underlines the usefulness of writing as a method for visualising mathematical processes and for developing the enhanced awareness of phases and areas for self-regulation in mathematics.

It appears that the voiceless thinking (Holton and Clarke 2006), within the test cycle's self-scaffolding, supports the immediate construction of knowledge, and together with reflective thinking tends to close the knowledge gap, completing the feedback loop (Boud 2000; Sadler 1989) and bringing the students' existing knowledge to a new level. The FSP test cycle tends to help students to express their voiceless thinking (Emig 1977).

The opportunity the FSP provides for students to rethink and supplement their answers, tends to make students more committed and motivated in their learning process, and in this respect, they are guided to become self-regulated learners. Feedback is provided in the FSP on all feedback levels (Hattie and Timperley 2007; Holton and Clarke 2006). The visualisation process within the FSP test cycle enhances the students' awareness of their strengths and weaknesses. Consistent with previous findings, scaffolding should be regarded as a metaphorical bridge, which provides students with confidence in their ability (Holton and Clarke 2006).

What we have learned during this project is that the engagement of students in PAR is a powerful way to let young people's voices be heard and to let their perspectives constructively influence teaching and learning. As a result of the students' engagement in the development of the FSP, the students enhanced their awareness of the social interplay at their schools. What we found was that PAR provides them with the empowerment to engage in transforming classroom practice and actually make a difference in their own education by the identification of local impediments to the achievement of their own positive educational outcome. The reflexive nature of PAR, with its iterative approach (plan, act and observe, reflect), brings support to the emancipatory practices of the educational context. Through the engagement as participating agents of change, the students are given a sense of control. This sense of control, which we regard as the key factor in PAR, provides them with inner strength and motivation to develop their role as citizens and contribute with democratic change not only locally but also in society in general. It can be concluded that the application of PAR empowers the students and plays an important role in their participation in and understanding of the teaching and learning process.

A possible limitation of the study is the limited number of participants in part two. The FSP and its test cycle were tested and developed over a decade, with over a thousand participants. These facts contribute to the validity and reliability of the programme. However, further studies of a more longitudinal character are needed to investigate the FSP's resemblance to SRL processes. It would also be of interest to collect further data to provide possible evidence of exactly how the FSP, in a stricter mathematical sense, enhances students' mathematical proficiency.

To summarise, it appears that the FSP has the ability to provide students with a sense of control by helping them visualise the learning process and by providing a true picture of their current level of mathematical proficiency. The FSP and, in particular, the test cycle, tend to alter the level and strength of self-efficacy and foster self-regulation (Zimmerman 2002).

It is reasonable to suggest that mathematics education needs to consider the development and encouragement of metacognitive functions, as well as the level and strength of self-efficacy and self-regulation, and the question is how to develop these aspects in students. We suggest that the FSP is a possible way. All students who were involved in the development of the FSP were radical agents of change by being a part of the development process for a teaching and assessment programme that aims to provide students with awareness of their metacognitive functions, to alter the level and strength of their self-efficacy, and to develop SRL processes.

The benefits of working in a formative scaffolding manner indicate that it is worth implementing the FSP on a larger scale and investigating its effects on both national and international levels. In future research, it would be of great interest to investigate the connection between working memory, self-efficacy and SRL. Could it be that the self-regulated processes working subconsciously within students are a reflection of their working memory? One thing is certain: students are more than capable of engaging in transforming classroom practice and being radical agents of change.

Disclosure statement

No potential conflict of interest was reported by the authors.

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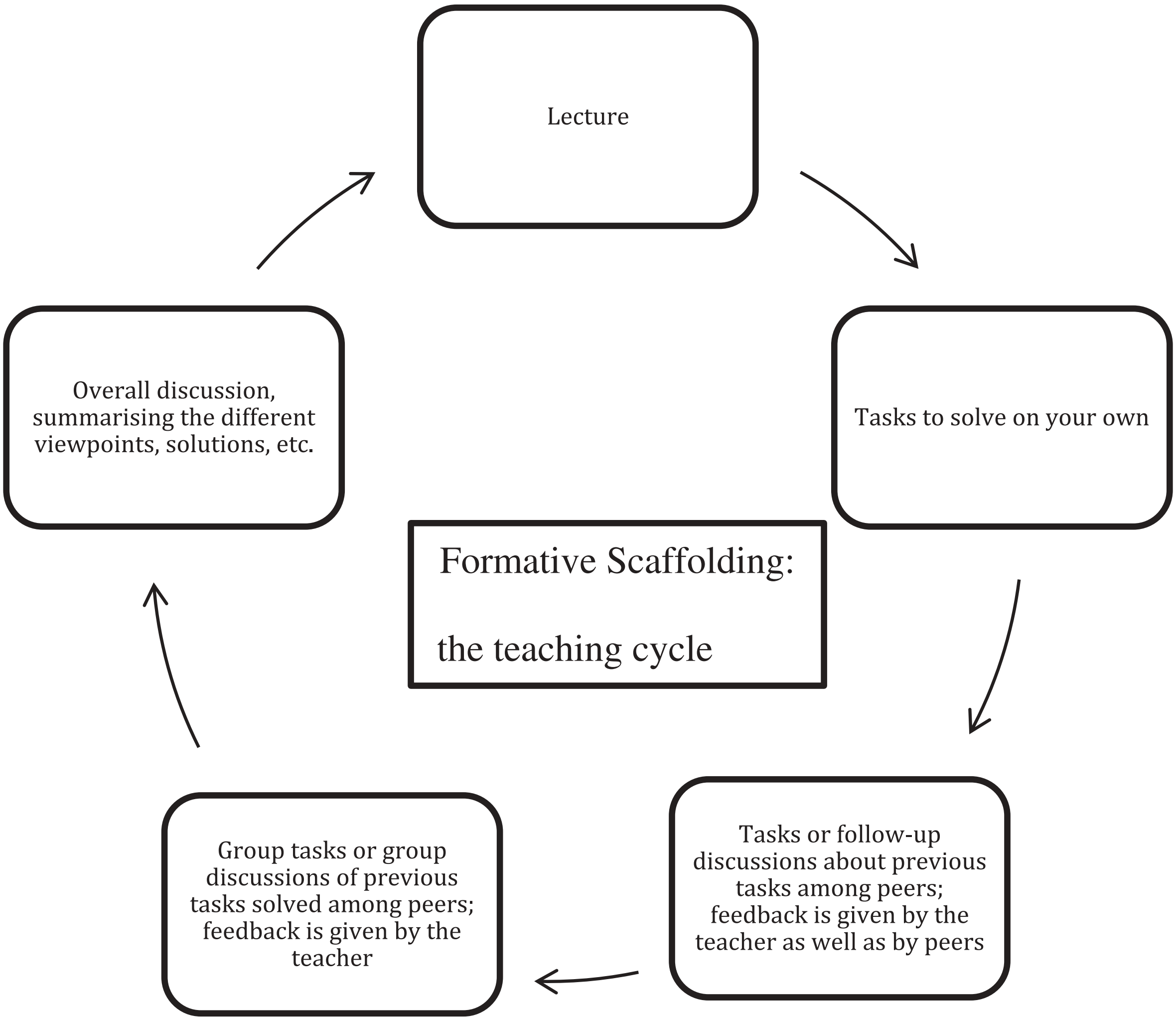
Appendix 1. Formative scaffolding: the teaching cycle

The cyclical process of formative scaffolding in the teaching process, making lectures and lessons meaningful.



Appendix 2. Formative scaffolding: the test cycle

The ten-step cyclical process of the FSP's teaching cycle and its application during a test situation in mathematics. A visual guide to how a test can constitute an additional opportunity for learning.