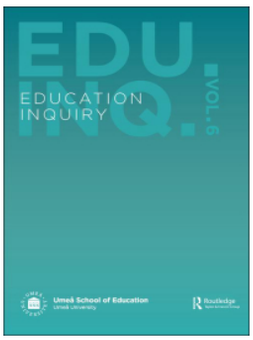

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Primary students' experiences of formative feedback in mathematics

Jenny Green

Department of Education, Communication and Learning, University of Gothenburg, Gothenburg, Sweden; Department of Mathematics and Science Education, Kristianstad University, Kristianstad, Sweden

ABSTRACT

Feedback does not always engage students. To better understand why this happens, the present study analysed Grade 2 (7- to 8-year-old) students' experiences of formative feedback in mathematics to identify aspects with potential importance for student engagement. The researcher processed the students' experiences with the help of stimulated recall and semi-structured interviews. Most of the students appreciated feedback that focused on the process, instead of simply offering solution methods. However, due to a conflict between teachers and students regarding the social and socio-mathematical norms, some of the students did not understand the purpose while others wanted the teacher to state the solution method. This shows that it is important not only which norms are established, but also that this is done at an early stage. Thus, both teachers and students need to understand and accept the norms, and potentially establish new norms, if the current ones are counterproductive.

ARTICLE HISTORY

KEYWORDS

Formative feedback; mathematics; primary students; socio-mathematical norms; student engagement; student views

Introduction

Feedback is a primary component of formative assessment, integrating both teaching and learning (Black & Wiliam, 1998; Hattie, 2009; Hattie &Timperley, 2007). However, students do not always engage with feedback (e.g. Brown & Glover, 2006; MacLellan, 2001); this can be due to both content factors, such as what the feedback focuses on (e.g. Havnes, Smith, Dysthe, & Ludvigsen, 2012; Jonsson, 2012), and contextual factors, such as when and how it is delivered (e.g. Jonsson, 2012; Rakoczy, Harks, Klieme, Blum, & Hochweber, 2013; Sidenvall, 2019). It is therefore relevant to examine how feedback is received, to determine which aspects of the feedback process are important for engagement. Currently, however, most research on this topic focuses on higher education or upper secondary school, while there is a lack of research on students' experiences and perceptions of teacher feedback (Antoniou & James, 2014; Hargreaves, 2013) in the primary school classroom, including mathematics classrooms. This indicates that there is limited knowledge regarding, for instance, whether the tendencies not to engage begin already at early stages. Hence, there is a gap in the literature regarding students' perspectives on feedback in primary schooling, as well as regarding the mathematics

CONTACT Jenny Green jenny.green@hkr.se Department of Mathematics and Science Education, Kristianstad University, 291 88, Kristianstad, Sweden

context. This study therefore focuses on younger students' experiences of formative feedback in mathematics, with an aim to better understand which aspects of the feedback process are important for student engagement.

Students' perspectives on feedback

Studies of primary students' perspectives on feedback have a common base, consisting of what students want from feedback and which processes they perceive as helpful (or not helpful) in improving their learning. According to Hargreaves (2013), primary school students prefer reminders, simple prompts, cues, or instructions, and their learning benefits when the teacher's feedback includes "substantial, but not burdensome" detail (p. 236). Eriksson, Boistrup, and Thornberg (2020) report similar findings, in which students appreciated the teacher giving "small clues". In the study by Hargreaves (2013), students expressed frustration when the feedback directed them too much, when the teacher tried to give them answers they could work out themselves, or when the teacher repeatedly gave them reminders they did not need. Similarly, in the study by Eriksson et al. (2020), a common description of "helpful feedback" entailed the teacher providing the students with new questions, making them reflect upon a task again. The students valued figuring out the solutions themselves, which they believed helped them to learn. They emphasised the importance of making an effort to learn, talking about it in terms of things they must do in order to learn (e.g. practice and "doing a lot of work, and doing things with quality"; p. 9). Gipps and Tunstall (1998) assert that students often relate success and failure to effort. Research by Palmér and van Bommel (2018c) shows that six-year-olds may find problem-solving tasks "fun", even if they have to struggle and their initial solutions are incorrect. In summary, students seem to be inclined to make an effort to figure out solutions on their own.

However, previous research has presented somewhat conflicting results. Although the students in the study by Eriksson et al. (2020) emphasised the importance of figuring out solutions themselves, they still appreciated attention from the teacher and became frustrated when the teacher tried to give helpful feedback to multiple students at the same time, experiencing a lack of attention. There also seems to be a difference in what students perceive to be "helpful feedback" and their conceptions of "effective feedback", depending on their interests and needs (Peterson & Earl Irving, 2008). For example, Hargreaves (2013) noted a difference between low-, and high-achieving students: While there was a tendency for low-achieving students to ask the teacher to tell them what to do rather than being receptive to repeated feedback, high-achieving students asked for more specific and frequent feedback.

There also seems to be a difference between teachers' and students' perceptions of effective feedback. For example, Murtagh (2014) showed that what teachers claimed were effective feedback strategies for supporting students' learning and motivation were not in line with students' perceptions. While the teachers believed there was value in marking every part of a task, e.g. using ticks, to show that a student's work had been "seen", this was not the case from the students' perspective. Instead, as Murtagh (2014) suggests, such a strategy could potentially undermine students' intrinsic motivation and lead to a culture of over-dependency. Furthermore, spending time on corrections may

be wasted time for teachers, as students do not always engage with such feedback (Williams, 2010).

Various types of feedback

Different categories and terminologies have emerged from research on teacher feedback and students' perceptions of it. For example, Tunstall and Gipps (1996a) identified four types of feedback, placed along a continuum from *evaluative* to *descriptive* approaches to assessment. The evaluative approach was strongly represented in response to the question of how the teacher helped students to make their work better. The authors describe valuative types of feedback as judgements made according to explicit or implicit norms, and descriptive types as feedback that more clearly relates to actual competence. Descriptive types are crucial to students' learning, are associated with formative assessment, and can lead to a mastery goal orientation, while evaluative types can lead to a performance goal orientation (Tunstall & Gipps, 1996b). Gamlem and Smith (2013) report similar findings, showing that improvement feedback is seldom given any attention in class. The findings in the study by Peterson and Earl Irving (2008) show that formative feedback was uncommon, especially in mathematics where feedback instead seems to focus on whether an answer is right or wrong (Boistrup, 2010). Other researchers presenting similar results are Burnett and Mandel (2010), who found that general, non-targeted praise was mostly used in the classroom, and Torrance and Pryor (1998) as well as Antoniou and James (2014), who noted that the feedback given in primary classrooms was characterised in terms of short-term rewards – praise or smiley face stickers instead of advice on how to develop. Hargreaves (2013) uses different terminology, categorising the teacher's feedback as given within a *convergent assessment framework* (working process of defining answers as right or wrong) rather than a *divergent assessment framework* (encouraging students to reconstruct their thinking, which emphasises the learner's understanding; Torrance & Pryor, 1998).

A pattern that can be seen in previous research is that it has focused primarily on gaining a deeper understanding of students' feedback practices in general, rather than examining students' experiences in specific feedback situations or specific subjects. The study by Murtagh (2014) investigating the feedback strategies employed by two experienced literacy teachers is an exception to this, as is the study by Gipps and Tunstall (1998), which focused on probing students' understanding of success and failure in relation to mathematics, painting, and reading.

It can be noted that students are often given feedback within a convergent assessment framework (Hargreaves, 2013), and it seems that most students prefer feedback that focuses on process rather than providing a ready-made solution. This study uses feedback designed to be in line with what students prefer, as shown in previous research. Accordingly, the research question is how students experience formative (process-focused) feedback on their reasoning in mathematics within a divergent framework, which compels them to generate their own solution methods and explain the underlying mathematics, which in turn require understanding (Hattie & Timperley, 2007). There is a lack of research in this area from the student's perspective, meaning

that important interactional aspects of students' responses to feedback are likely missing.

Theoretical framework

Social and socio-mathematical norms

The theoretical framework for this study is based on Cobb and Yackel's (1996) model, which consists of a combination of observing and analysing the development of social and socio-mathematical norms and observing the individual student's activity during classroom activities. The model includes an interrelationship between two perspectives: the individual/psychological and the social/collective. These two perspectives are interdependent, and neither exists independently of the other. In the model, social and socio-mathematical norms thus have a counterpart in the individual perspective that is constructed and revised in parallel. This study examined the students' experiences of formative feedback on their reasoning in mathematics. The individual perspective refers to views (called "beliefs" by Cobb & Yackel, 1996), which can be understood as individuals' understandings derived from experience. Hence, an analysis of the students' experiences of the formative feedback in relation to norms was relevant because there is an interrelationship between the individual perspective (views) and social and socio-mathematical norms (Cobb & Yackel, 1996).

Social norms are general and apply to many different activities – that is, they are not unique to mathematics – and consist of the interaction between the individuals (students and teachers) in the classroom. At the individual level, this includes the students' views of their own role, the roles of others, and general mathematical activity. The individual makes his/her interpretation of what the social norm in the classroom entails. A social norm could involve, for instance, that students are expected to explain their solutions and how they reason (social perspective). However, this norm may need to be renegotiated if it does not correspond to the individual perspective (students having their own ideas about which norms apply); for example, students may feel that the teacher should simply check whether a student has found the correct solution, instead of focusing on the process. The social norms regulate and construct participation, and are established as a form of agreement within the whole group. If the social norms, developed in the interaction between teachers and students, emphasise the value of the students finding the correct answer to a given task, then this will create a mathematics classroom that significantly differs from one in which the norm is that students should be able to discuss different solutions to various tasks or problems.

Just as agreements form social norms in the classroom, agreements specifically linked to teaching and learning in mathematics form "socio-mathematical norms". These norms govern, for example, the learning of mathematical concepts and methods, or what constitutes a mathematically acceptable explanation, a different solution to a problem, or an effective or aesthetically pleasing solution (Cobb & Yackel, 1996; Yackel & Cobb, 1996). These norms regulate the interaction between students, teachers, and the subject, and form the basis for mathematical practice. Created and changed in the interaction between students, teachers, and mathematics, they are of great relevance for students' mathematics learning (Kazemi & Stipek, 2001). If the social and socio-mathematical norms are not conducive to students' mathematics learning, they may

need to be consciously influenced. The teacher cannot establish these norms alone, but rather initiates and guides the renegotiation that may need to take place when there are conflicts between the teachers' and students' views. The emergence of conflict often makes the current state of the norms visible (Cobb & Yackel, 1996).

In this study, students were challenged with process-focused feedback, and their experiences and possible norm conflicts (instigated by the feedback provided) between the teacher, the individual student, and the subject of mathematics were analysed in relation to the social and socio-mathematical norms. The social and socio-mathematical norms correlate to the views on roles and general mathematical activity, as well as mathematics and mathematics learning, that prevail in the classroom; namely, who is expected to do what, and what is perceived as the proper way to do things in mathematics, mathematics learning, and mathematics teaching.

Method

To answer the research question, a problem-solving task and a formative feedback guide (Appendix 1) were designed, allowing for a problem-solving lesson to be observed and followed up in an interview. The data collection was conducted in two main steps: Student Meetings #1 and #2. Meeting #1 consisted of three lessons with three classes (one lesson per class), and Meeting #2 of 15 stimulated recall sessions (one session per student). At Meeting #1, the students received the problem-solving task that they were to solve during observation and video recording. During the lesson, the teacher gave each student formative feedback according to a feedback guide that had been introduced at a workshop and practiced during a previous lesson. In connection to the teacher's feedback, the researcher observed whether the students acted upon it. At Meeting #2, the researcher examined the students' experiences of the feedback through video-recorded stimulated recall sessions held with each student.

Participants

To avoid the students' experiences being based on an individual teacher's ability to give feedback, and to get a distribution of the students regarding performance and ambition level, the number of students was set at 15 across three different classes, with three voluntary teachers selected by the headmasters in a medium-sized municipality. Each teacher helped to select suitable students, as the researcher did not know them. It was important to have a balance between who the teacher believed would feel comfortable in the situation and who might be able to express their thoughts, especially as the students were only eight years old. The selected students were then asked to participate, and their parents gave informed consent. The teachers' work experience varied between 11 and 16 years.

Student Meeting #1

Problem-solving task

The selection criteria for the problem-solving task were that it should be easy to understand and that everyone was to have an opportunity to work with it at different levels of difficulty, and at the same time it should be perceived as challenging and have

multiple possible solutions. In this way, the students could receive nuanced and process-focused feedback, focusing on their problem-solving and reasoning (Appendix 2).

Process-focused feedback

The students received process-focused feedback in which their understanding of the mathematics in the task was central. Using feedback, the students were challenged to argue for their solution based on a set of questions, thus creating a focus on the underlying mathematics. In the feedback situation, they were given the opportunity to follow and assess their own arguments (conduct mathematical reasoning). Thus, with reference to the previously mentioned feedback types, the feedback in the current study was given within a divergent assessment framework. The teacher provided feedback according to an adjusted version of the feedback guide used by Sidenvall (2019; where justification and further descriptions are found), which assisted teachers in assessing students' problem-solving, as well as providing formative feedback, without suggesting a specific solution method.

Video recording and observations

The lesson was recorded on digital video. However, only the students' voices and hands, their solutions, and any materials they used (e.g. money, blocks, crayons) were recorded. Even though the solutions were recorded, the focus of the video recordings was not their problem-solving per se. Instead, the recordings were used as a starting point in the stimulated recall sessions.

According to Sidenvall (2019), it can be expected that some students lack the motivation to act upon the feedback they receive. While the researcher was mindful of this during the observation, it did not occur.

Student Meeting #2

Stimulated recall

The researcher processed the students' experiences with the help of video-recorded stimulated recall sessions with them one day after the feedback sessions. The purpose of using stimulated recall was partly to remind the students of how they had experienced the feedback they received, and partly to help them to remember the feedback situation. The students watched sequences in which the teachers had provided them with feedback, and were told that they could stop the film whenever they wished or if they wanted to say something. They agreed that the researcher could do the same. The stimulated recall was used in conjunction with a semi-structured interview, to be able to follow up on what the students said (Robson, 2011). A semi-structured interview guide with questions related to the feedback (e.g. why the teacher said what she said, or whether there was something the student wanted the teacher to say) was used. To avoid missing out on potentially relevant aspects when asking the students questions, for example that a student wanted task-focused rather than process-focused feedback, the questions were formulated to capture experiences of feedback at different levels. To do this, the researcher used Hattie and Timperley's (2007) theory of feedback (task, process, self-regulation, and self-level). The questions were formulated in a way that

minimised the risk that the students would misunderstand them, for example not using the concept of feedback but instead language that was sensitive to the students' vocabulary (Punch, 1998). Great care was taken to ask the questions in a curious rather than judging manner, as well as to encourage the students to answer the questions truthfully rather than aiming to please the researcher. To reduce the risk of students not answering truthfully, the researcher tried to be as clear as possible about the research project, the framework, and what it meant to engage in the project. The researcher adopted an active listening approach and sometimes asked questions to confirm what the students had said, and followed up on their answers. The students were assured that what they said would be treated confidentially, and were reminded that they were free to withdraw at any time. No student interrupted any interview. The interviews lasted between 23 and 50 minutes.

Data analysis

The interview data was analysed and interpreted to look for phrases with information describing the students' experiences. The phrases were sorted into dimensions of similarities in experiences, and dimensions that were expressed differently but were similar in meaning were then grouped into four categories reflecting the key messages in the interviews (in line with meaning condensation, described by Brinkmann & Kvale, 2015). In some cases, the same student expressed experiences that fell into more than one category.

Views were then extracted from the categories and related to social and socio-mathematical norms, respectively. Statements concerning the students' view of their own role and the roles of others were related to social norms, and statements concerning the notion of mathematics, mathematics teaching, and mathematics learning were related to socio-mathematical norms. As the category content could not be perfectly split across the norms, some content was related to both social and socio-mathematical norms. An analysis was then made to determine whether the views were *in line* with the purpose of the feedback, were *not in line* with it, or were *neutral* in this respect.

Results

This section presents how the students described their experiences of the formative feedback, and focuses on the following four categories:

A. Guidance for understanding
B. Create your own solution method
C. Do not understand the purpose
D. The teacher has to specify the solution method

The number markings in parentheses indicate different students. Expressions without number markings are represented by more than one student. (R) denotes the researcher.

A. Guidance for understanding

The majority of the students felt that they received guidance during their solution process and that the teacher's feedback contributed to increased understanding. The statements in this category focus primarily on learning, with understanding constituting a prominent aspect. Several students expressed that the teacher "made them understand more", or that the teacher's feedback was a "kind of explanation".

Appreciated help with strategy suggestions

The students appreciated receiving suggestions for strategies that could be used to solve the task, or suggestions for a strategy to improve the result (both involving process-focused feedback). The suggestions included both strategies that they normally used and those that they did not normally use. It was often sufficient to receive suggestions for such strategies so that they could move forward in their problem-solving process.

There was an openness among the students in their way of thinking and thereby in how one can proceed to solve the task. For example, one student expressed that she was happy to receive a suggestion for an alternative strategy. Sometimes, students did not realise that suggestions for materials to be used could be the same as suggestions for a strategy. One student expressed, for instance, that he had not received help in solving the task but only "help with the materials" (2), at the same time as he expressed that it was all he had needed and that the feedback had indeed been helpful.

The solution process develops

The questions that the students received as part of the feedback started a process whereby they could come up with answers and find other possible ways of thinking. The key was thus not *only* to find a result. It was specifically stated that the feedback was helpful because the teacher wanted to know how the students had reasoned and why they had solved the task the way they had. In this way, the students were challenged in their thinking. One student expressed that it was helpful to be able to "put into words" what she was thinking (4). Hence, the feedback contributed to developing the students' solution process. One student specifically expressed that he had been about to give up, but that the feedback had helped him not to. In this way, the feedback created motivation as it included the student in the solution process. When the feedback helped him develop the solution process he expressed joy, and it helped him to "not give up" (3).

The students expressed a focus on solutions "being correct", and consequently wanted to check their solutions along the way, i.e. argue for the underlying mathematics. The students expressed that it was helpful to get questions from the teacher that could reveal errors in their thinking, even if at the same time they could experience that it was difficult to answer them.

B. Create your own solution method

Most of the students expressed that it was helpful for them to think for themselves in order to create a solution method for the task they were working on, and that they liked

the feeling. This shows that the students wanted to have autonomy, to make an effort in engaging in mathematical reasoning, and to solve tasks by themselves.

The students perceived the teacher's questions as helpful, as they required the students to think. It was fun to answer them, as it made them curious to find the answer. The students emphasised the importance of being left alone for a while. They believed that this was how they were given the opportunity to finally come to a solution themselves. They expressed that it felt good that the teacher went and helped others in the meantime, because this allowed them to figure out the solution themselves; in addition, they expressed that it was "quite easy" to do it:

> If you'd known what a fish costs, you would've been able to calculate for all fish; it would've been really easy. I need to figure it out. I needed to think a lot. It feels good that she leaves me. (7)

This shows not only the importance of allowing students to create solution methods for themselves, but also the importance of having the confidence that they are able to do so. As it turned out, the teacher's questions initially helped the students to better understand the task, and then they expressed a need to "figure out a little", and that if you "don't understand" you can ask for help again. One student expressed that he used to receive "overly easy help" (13), by which he meant that he often came up with solutions far too easily. This can be interpreted as there being a desire for feedback that provides clues but does not reveal exactly how to figure the solution out.

C. Do not understand the purpose

Several students expressed that the feedback felt, or was, good, but they could not explain why. Some had not reflected on the fact that the teacher did not specify a solution method, and some had difficulties answering questions related to their experiences of the feedback and the feedback situation. For example, some students had difficulty answering why they thought the teacher asked them questions, and why the teacher wanted to know how the students had reasoned and how they had figured out the answer.

In some cases, students considered "everything" about the feedback and the help provided to be satisfactory, and felt that the teacher had said "the right things". However, no specific answer could be given as to what "everything" meant or in what way the feedback had helped them to move forward in their solution process. The statements show that some of the students could not fully see the point of the feedback.

Overall, the students expressed no desire for the feedback to be given in any other way, except that some of them specifically expressed that they wanted the teacher to provide a solution method; i.e. to be clearer about the objectives of the task and how the students should proceed to solve it.

The teacher's questions felt strange

Some students found it strange that the teacher wanted to know how they had reasoned, whether the solution could be correct, whether they could explain in their own words what was required, or whether they could present their answer. This shows that the students had a different view of mathematics and mathematics learning than what the

teacher conveyed through the feedback, the students focusing on neither the solution process nor their own learning.

It felt safe that the teacher "has got your back"

Several of the students discussed how they solved the task instead of reflecting on the actual feedback situation, which can possibly be interpreted as having a performance focus. These students experienced that the teacher wanted to help them and expressed that it felt good when the teacher tried to do this, which shows that they had no predetermined expectations of the mathematics teaching.

The students also appreciated receiving help, although they did not reflect on what it meant to receive help in this context. The teacher not always being available could be perceived as "tricky", as it meant that the students were left alone without a definitive answer to the task. Views about the teacher's role were expressed in different ways, such as "you didn't get any help" but you "managed anyway", or that the teacher asked questions to check that the given answer was correct (if the teacher had known that the students had the correct answer, she would not have asked). The notion that "the teacher wants to know" reflects a view that the teacher checks the answers and is expected to have this role. Another view was that the teacher herself did not have answers to the questions that were asked, and thus appreciation was expressed regarding the teacher's own effort:

> The teacher didn't know; she tried really hard to help me and that felt good, because she helped me a little. (4)

D. The teacher has to specify the solution method

Some students had a different opinion about mathematics teaching and who does what in the mathematics classroom. They found it difficult to answer the teacher's questions due to emotional aspects, and/or felt the teacher should provide a solution method.

The students had difficult feelings

For some students, the feedback generated difficult feelings as they did not understand or could not explain their solution. An example linked to emotional aspects is that the feedback could create uncertainty; you immediately felt that you had done something wrong. The feedback situation could also feel embarrassing when difficult questions were asked. These students mentioned a desire to get confirmation at the task level (whether their answer was right or wrong), and if it was wrong, the teacher should help them to solve the task:

> So, you don't really like that she didn't tell you what to do. The question is why you think so. (R)
> Because it feels embarrassing. (8)

Different expectations of the teacher

Among a few students, there was an expectation that the teacher should provide a solution method. They expressed this in various ways, such as the notions that the students "shouldn't have to come up with the answers themselves" and that it was

"somewhat boring in the feedback situation because you wanted to know what to do", or that there were too many questions.

When it became difficult and the students did not know what to do in order to move on, they simply had to raise their hands. The teacher would then provide more "clues" to help them in their solution process:

> She shouldn't provide the entire task; I just wanted to know how much a fish costs, because I couldn't figure that out. (9)

In general, the students were quick to ask for help if they "got stuck", which can be interpreted as their having a focus on quickly finding (correct) solutions and this potentially being what they perceived that mathematics and learning in mathematics are about. One student expressed that she "forgot the work" (7) she was doing when the questions were to be answered. A focus on finding the "right answer" can be interpreted as the process being less important and the focus mainly being on results or performance.

Summary of analysis

The students' views in relation to the prevailing norms

As mentioned, each of the prominent views was related to its corresponding norm. The data suggests that the students had a desire to learn and that several of them focused on the entire solution process, i.e. the underlying mathematics, instead of merely finding solutions. They perceived it as natural to check their solutions and to be able to come up with solution methods themselves, and suggestions for strategies were usually all that they needed. Thus, it can be said that there was generally a learning-oriented approach among the students. They did not seem to focus on their current ability or how it was assessed, but instead on the value of developing their capability; they also had an interest or saw value in solving the task. They used the obstacles they encountered to increase their efforts or to analyse and develop their strategies.

However, a performance-oriented approach was also observed among the students. Not all of them focused exclusively on the process; some rather expressed that they wanted to move forward quickly and finish the task. They expected the work to go quickly and easily, and expected the teacher to specify the solution method or give clues. They also had a strong focus on the teacher being the one who checked the answers and on the importance of having the correct answer. Hence, some students and the teacher had different views of mathematics and mathematics learning in the new feedback situation (concerning the socio-mathematical norms; Cobb & Yackel, 1996). Some students also had different views of their own role and that of the teacher, concerning the established social norms. In a way, there seemed to be a conflict between the teacher (or, more specifically, the purpose of the feedback) and some students when they held different views on the socio-mathematical norms. The social norms that prevailed in the mathematics teaching context were both compatible and incompatible with the roles reflected in the feedback the students received.

At the same time, some students expressed neutrality in their views of how mathematics learning should work and about who does what. This can be interpreted as meaning that what the teacher says and does is what is right. Some students expressed

that they did not fully understand the purpose of the feedback – that the teacher asked "strange questions" – but that they still perceived the feedback as helpful and had no desire for the teacher to do or say anything different. No conflict arose in these cases, as the students had no expectations regarding mathematics learning, how to learn, or who should be doing what; i.e. the socio-mathematical and social norms were neutral in relation to the purpose conveyed by the feedback.

Table 1 summarises the social and socio-mathematical norms that were established and which views were in line with the purpose of the feedback, which were not, and which were neutral. The views are extracted from the categories (A-D) in the *Results* section of this text.

Discussion

Important aspects for engagement

The aim of this study was to find which aspects of the feedback process are important for student engagement. Different students experienced the feedback context differently, likely because they did not have the same views regarding their own role or those of others or mathematics learning (referring to the social and socio-mathematical norms; Cobb & Yackel, 1996). In this study the teacher's role was to provide feedback directed at the problem-solving process instead of focusing on the answers, while the students' role was to create solution methods and explain the underlying mathematics. Although there were partially different views on mathematics and mathematics learning between the students and teachers in the new feedback situation, this did not keep the students from acting upon the feedback by arguing for their solutions. This suggests that there is a potential for formative, process-focused feedback. Research showing that students may lack motivation and do not act on process-focused feedback (because they have the view that the teacher should guide students through difficulties; Sidenvall, 2019) has applied in regard to older students. However, these tendencies seem to also exist in primary school (although this is not visible in their actions), and it is reasonable to believe that it is of importance which social and socio-mathematical norms are established at an early stage. In the long run (at later educational stages), it is likely that both teachers and students need to understand and accept the social and socio-mathematical norms in order for feedback to be acted upon, and may even need to establish new norms if there are conflicting views.

It is likely possible to make performance-oriented students more learning-oriented through formative feedback, as students' goals are not personal characteristics but are rather highly influenceable and a result of their previous learning experiences (Stipek, Salmon, Givvin, & Kazemi, 1998). However, this may take some time (Hargreaves, 2013) as social and socio-mathematical norms need to be renegotiated, which takes place in the interaction between students, teachers, and the subject (Cobb & Yackel, 1996). Even if a teacher cannot establish norms him/herself because the norms are established in collaboration with the students, the teacher still has a great deal of influence over which socio-mathematical norms should apply as well as a responsibility to establish them. To change the socio-mathematical norms, teachers first need to be aware of the prevailing norms, which can be difficult as these are difficult to detect if

Table 1. Summary of views per norm.

	Views in line with the purpose	Neutral views	Views not in line with the purpose
Social norm	• Expectation that the teacher should not provide a solution method (B) • Helpful to describe how you have reasoned (A)		• It is the teacher who controls the answers and it is the teacher's task to do so (C) • The teacher has to provide a solution method (D) • The teacher's task is to help the students, preferably quickly (C) • The students should not have to come up with the answers themselves (D) • The students do not understand why they should motivate their solutions and explain how they have reasoned (C)
Socio-mathematical norm	• Helpful to get suggestions for strategies, including alternative strategies (even those they would not normally use) (A) • The guidance given was helpful for them in coming up with answers and other ways of thinking (A) • The key is not only to find a solution (A) • Process is relevant (A) • Understanding is relevant (A) • Curiosity exists (B) • Desire to learn exists (A), • Fun to answer questions (B) • Helpful to put into words how you have reasoned (A) • Relevant aspects: – checking your solutions (A) – thinking for yourself (B) – solving tasks on your own (B) – creating solution methods on your own (B) – effort (B) – the feeling of doing something on your own (B)	• Uncertain what help in mathematics means and how to learn mathematics in the best way (C) • No expectations on how mathematics learning should work (C)	• The teacher asked strange questions (C) • Focus on performance (C, D) • Focus on the correct answer (D) • No focus on the process, or on your own learning process (C, D) • Wanted to move forward (D) • Show that you did not get any help and that you are able to manage anyway (C)

no-one or nothing breaks or challenges them. In the present study, students received feedback that was different from what they were used to, which made the prevailing norms visible.

Different students prefer different types of feedback

Previous research shows that students generally receive ready-made solutions, but it seems that most of them prefer process-focused feedback, meaning that the classroom norms are of importance. The majority of the students in this study appreciated process-focused feedback instead of being given solution methods and, overall, the findings here confirm the results of previous research regarding students' expectations on feedback (see Burnett & Mandel, 2010; Eriksson et al., 2020; Gipps & Tunstall, 1998; Hargreaves, 2013; Palmér & van Bommel, 2018c). However, this study also found that students considered it important to be left alone for a while, as opposed to what Eriksson et al. (2020) found.

In line with what Burnett and Mandel (2010), Hargreaves (2013), Murtagh (2014), and Williams (2010) presented, the students in this study experienced feedback in different ways and preferred different types of feedback. Some of them expected the teacher to provide a solution method, felt that the students should not have to come up with the answers themselves, or lacked an understanding of why they should motivate their solutions. This could indicate that this study's participants may have been in an evaluative/convergent mathematics classroom context (Gamlem & Smith, 2013; Hargreaves, 2013; Murtagh, 2014; Peterson & Earl Irving, 2008; Tunstall & Gipps, 1996a). These students expressed that it was frustrating when they were left alone without definitive answers to the questions, which in this case confirms the finding in the study by Eriksson et al. (2020). Being in such a context can lead to students ending up in what Murtagh (2014) describes as a culture of over-dependency, losing their intrinsic motivation and instead focusing on quick solutions and correct answers, but without proving why, which seems to be common in mathematics classrooms (Boistrup, 2010). The students who expressed neutrality in their views can be assumed to have an (unspoken) idea that the teacher is the authority and thus the one who decides, and that the students have to adapt accordingly by following the provided instructions and activities, and are fully satisfied with this arrangement.

Limitations and further research

Strengths of this study include that it investigated formative feedback within a mathematics context, providing results specific to mathematics as well as discerning important aspects for student engagement through interviewing the students themselves and how they interpret and make use of teachers' feedback. The latter could also be a limitation due to the low age of the students, as younger students may have difficulty verbalising their experiences (Doverborg & Pramling, 1993). Another limitation to bear in mind when interpreting and generalising the results is that the selection of students was based on who the teacher believed would feel comfortable in the situation and also be able to express themselves, which may have resulted in a group that was already open-minded to formative feedback.

It is known that formative feedback contexts can be problematic – there can be a lack of motivation and no response to feedback among students (Sidenvall, 2019). The question is: What happens if mathematical classroom norms foster other views, in which learning mathematics does not mean applying procedures? Would this promote more learning autonomy and encourage students not to rely (to such an extent) on an external authority, e.g. the teacher? In order to even better understand this, there is a need for more research in the area, for instance by providing process-focused feedback over an extended time period to students and observing whether there are any changes in their engagement and experiences.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributor

Jenny Green is a PhD student in Subject Matter Education with specialization at the Department of Education, Communication and Learning at the University of Gothenburg. The aim of the thesis is to understand the conditions of the formative feedback practice in mathematics. Her thesis presents a qualitative study based on interviews, with focus on feedback from a student perspective, in primary and upper secondary school classrooms. The present paper will be included in the thesis

ORCID

Jenny Green http://orcid.org/0000-0002-3691-0431

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Diagnostic questions:

1. Can you, in your own words, tell me what you should answer/figure out/solve in the task?
2. What have you done/how have you reasoned up to now?
3. Why have you done it/reasoned that way?

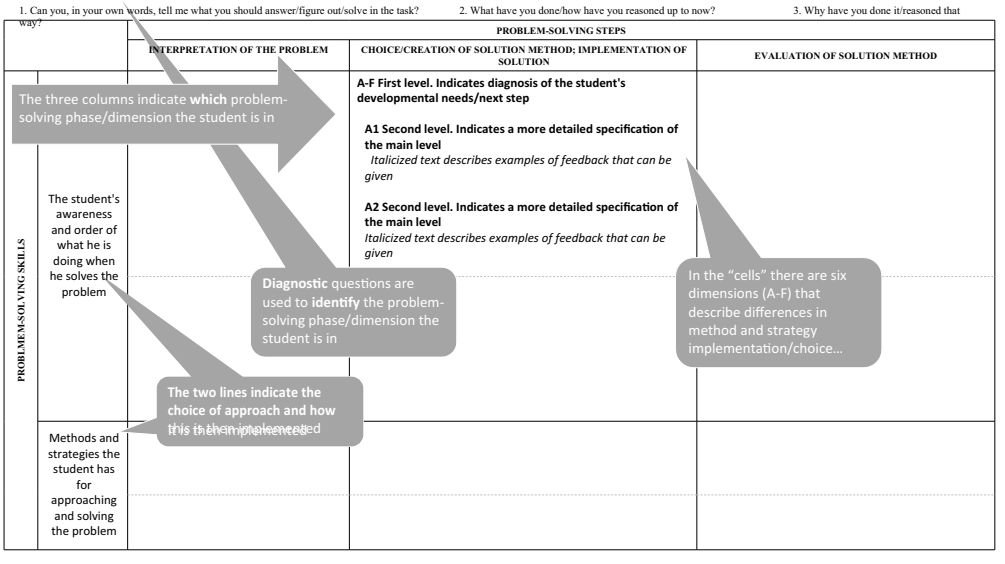

Fig. 1. Study area with the location of the sampling stations.

		PROBLEM-SOLVING STEPS		
	INTERPRETATION OF THE PROBLEM	**CHOICE/CREATION OF SOLUTION METHOD; IMPLEMENTATION OF SOLUTION**	**EVALUATION OF SOLUTION METHOD**	
PROBLEM-SOLVING SKILLS	The student's awareness and order of what he is doing when he solves the problem	***The student does not realise that his interpretation is incorrect*** *Examples of feedback*: •Read the task aloud •Do you understand the words used in the problem? •What are you going to find or show? •Can you now explain what information is available and what answer you should find? ***The student does not realise that he missed important information in the assignment*** *Example of feedback*: •Is there information in the task that can give you an idea of what to do?	**A. The student does not realise that the *chosen approach* to exploring the problem or the creation of a solution method *does not lead to* an appropriate solution to the problem** **A.1. Wrong overall approach** *Example of feedback*: •I see that you are trying to solve the problem by (summarise the wrong approach, but do not describe what is wrong). Can you tell us how you reasoned here and how it will help you solve the problem? **A.2. Local error in part of the approach** *Example of feedback*: •I see that you are trying to solve the problem by (point out the part of the approach that contains the error, but do not describe what is wrong). Can you tell me how you reasoned here and how this part will help you solve the problem?	**A. The student has a solution method that he is trying to implement, but *does not realise that the solution method is incorrect*** *Examples of feedback*: •Can you tell me why this way of solving the task works? •Why is the answer X? •Can you show that you have found the right solution? •Can you verify your solution in any way? •Is your answer reasonable?
			B. The student has *interrupted* the attempt to explore or create a solution method, and/or is unable to choose an appropriate approach **B.1. The student has made a good attempt to explore or create a solution method, but is stuck** *Example of feedback*: •Can you move forward in any way with what you have done so far? **B.2. The student's attempt is not good enough to build on** *Examples of feedback*: •Would you be able to solve the task in any other way? •Can you spot something that is wrong?	**B. The student has a solution method that *he thinks or knows may be incorrect*, but *is unable to verify*** **B.1. The student has made a good attempt to verify his solution method, but is stuck** *Example of feedback*: •Here you have done this; you can move on with what you have come up with so far (aimed at the part of the attempt that can be developed) **B.2. The student is unsure whether the solution method is incorrect, but does not try to determine whether this is the case** *Examples of feedback*: •Can you tell me why this way of solving the task works? •Can you somehow check the answer? If so, how?

(*Continued*)

(Continued).

		PROBLEM-SOLVING STEPS	
	INTERPRETATION OF THE PROBLEM	**CHOICE/CREATION OF SOLUTION METHOD; IMPLEMENTATION OF SOLUTION**	**EVALUATION OF SOLUTION METHOD**
	Methods and strategies the student has for approaching and solving the problem		**D. The student *tries but finds no* suitable strategy for exploring or creating a solution method** *Examples of feedback*: •Try to draw a picture/make a table/solve a simpler version/divide the solution into different steps/ make a diagram/use concrete material/guess and try/look for patterns (or another strategy; choose suitable) •Are there any calculations you need to do? Choose calculation method
			E. The student is *about to* formulate a good strategy for exploration or create a solution method, but *does not quite reach it* *Example of feedback*: •Summarise what is good and lead to what needs to be developed (without specifying a solution method)

	PROBLEM-SOLVING STEPS	
	INTERPRETATION OF THE PROBLEM	**CHOICE/CREATION OF SOLUTION METHOD; IMPLEMENTATION OF SOLUTION**	**EVALUATION OF SOLUTION METHOD**

(*Continued*)

		PROBLEM-SOLVING STEPS	
	INTERPRETATION OF THE PROBLEM	**CHOICE/CREATION OF SOLUTION METHOD; IMPLEMENTATION OF SOLUTION**	**EVALUATION OF SOLUTION METHOD**
	Methods and strategies the student has for approaching and solving the problem		**D. The student tries but finds no suitable strategy to verify his solution method** *Example of feedback*: •Try to draw a picture/judge if it is reasonable/try to find examples where it is not true/if you look at what you did in the previous task, can it be true then?
			E. The student is about to formulate a good strategy for verification, but fails with the last steps *Example of feedback*: •Summarise what is good, lead the way to what needs to be developed

(Continued).

	PROBLEM-SOLVING STEPS			
	INTERPRETATION OF THE PROBLEM	**CHOICE/CREATION OF SOLUTION METHOD; IMPLEMENTATION OF SOLUTION**	**EVALUATION OF SOLUTION METHOD**	
PROBLEM-SOLVING SKILLS	The student's awareness and order of what he is doing when he solves the problem		**C. The student realises that the *chosen approach* to exploring the problem or the creation of a solAution method *leads to* an appropriate solution to the problem** **C.1. Wrong overall approach** *Example of feedback*: •I see that you are trying to solve the problem by (summarise the correct approach, but do not describe what is correct). Can you tell us how you reasoned here and how it will help you solve the problem?	**C. The student has a solution method that he is trying to implement and *realises that the solution method is correct*** *Examples of feedback*: •Can you explain to me what you have done and how you have reasoned? •Can you show that you have found the right solution? •Can you verify your solution in any way? •Are there different ways to do this? •Can you tell me why this way of solving the task works? •Why is the answer X?
	Methods and strategies the student has for approaching and solving the problem		**F. The student *finds* a suitable strategy for exploring or creating a solution method** *Example of feedback*: •Summarise what is good, without specifying the solution method	**F. The student has formulated a good strategy for verification** *Examples of feedback*: •Can you draw any conclusions from what you have done? •Could you solve the task in a different way? With other strategies methods? •What is a more or less efficient/smart/good solution? •Has working with the problem given you new knowledge? If so, what? •Are there more solutions to the problem? •Have you worked with a similar problem before? Compare.

The fish problem

Kim is about to buy fish for his aquarium. At the pet store, 4 fish cost SEK 10.

a) How many fish can Kim get for SEK 20?

b) How many fish can Kim get for SEK 15?

c) How much do 10 fish cost?

d) At the same pet store, Kim has previously paid SEK 12 for 16 fish. How much did 28 fish cost at that time?