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The role of feedback and working memory for goal-related monitoring and goal revision

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ABSTRACT

Background: Goal revision in response to performance feedback is a highly important self-regulatory process. A central requirement for goal revision is the ability of learners to accurately judge their performance relative to their goals, i.e., goal-related monitoring. However, the determinants of accurate goal-related monitoring and goal revision remain poorly understood. School children may have particular difficulties in accurately monitoring their goals and performance and revising their goals accordingly.
Aims: The study (1) examined the determinants of accurate goal-related monitoring and adaptive goal revision and (2) tested feedback as a means of promoting accurate goal-related monitoring and adaptive goal revision in elementary and early secondary school children.
Sample: Eight-to eleven-year-old children ($n = 106$) participated in the study.
Methods: Children participated in a series of quizzes. They set performance goals before each task and then rated their performance. Children either received feedback on their goals and task performance (feedback condition), or they received no feedback (no feedback condition).
Results: Children generally overestimated their performance, especially those with lower working memory. Children in the feedback (vs. no feedback) condition (1) became more accurate in their goal-related monitoring and (2) revised their goals more adaptively over the course of the experiment.
Conclusions: The results highlight the role of interindividual differences in working memory for goal-related monitoring and goal revision, and underscore the effectiveness of feedback in promoting these metacognitive skills.

1. Introduction

Goal monitoring and goal revision from one study session to the next are central components of self-regulated learning. Self-regulated learning (SRL) involves a cyclical process (Zimmerman, 2000): Before studying, self-regulated learners set goals and plan their actions. During studying, learners monitor their goal progress. After studying, learners evaluate their goal progress by comparing their goals to their current learning state. Learners thus generate internal feedback about goal success or failure, which should encourage goal revision in the next study session. This means that a critical component of SRL involves the use of metacognitive skills. Metacognitive skills include the ability to monitor one's goals and performance and to use this information to regulate future study decisions (Nelson & Narens, 1990). For example, learners may prepare for an upcoming exam by completing a series of practice exercises, such as math problems, in a textbook. For each study session, learners set a goal for how many of the available practice exercises they would like to solve. After studying, learners may find that they have fallen short of this goal. For example, they may have completed fewer exercises than intended, which should affect their goal for the next study session. Learners may lower their goal so that the new goal reflects their actual level of performance. Thus, goals are not static, but learners should revise their goals dynamically over time. In summary, adaptive goal revision is an essential part of the cyclical SRL process.

Although students face challenges that require adaptive goal

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revision, it is largely unclear how they set, monitor, and revise their goals. There is a large body of research addressing the initial adoption of goals (Locke & Latham, 2013). However, relatively little research has focused on whether and how goals are revised following goal success or goal failure. The ability to set achievable goals, assess one's performance, and revise goals based on performance feedback are important skills related to students' academic success. These skills have been associated with higher academic achievement (Dent & Koenka, 2016), higher motivation (Schunk & Zimmerman, 2008), and more positive emotions during learning (Pekrun et al., 2002). A better understanding of how students monitor and revise their goals, and how this competence can be fostered, is therefore crucial.

1.1. The role of metacognitive skills and working memory for goal-related monitoring and goal revision

A central requirement for adaptive goal revision is that learners accurately judge their performance relative to their goals. In the present study, we refer to this ability as goal-related monitoring. We focus on two aspects of goal-related monitoring: goal calibration and performance monitoring. Goal calibration refers to the discrepancy between the learner's goal set before the start of the task and the learner's actual performance. The smaller the discrepancy between the goal and actual performance, the more accurate the goal calibration. In other words, more accurate goal calibration indicates that learners are better able to judge what goal level they can achieve because the goal is more closely aligned with later performance. Performance monitoring refers to the discrepancy between the learner's retrospective performance estimates after completing the task and actual performance. The smaller the discrepancy between the learner's retrospective performance estimate and actual performance, the more accurate the performance monitoring. Taken together, goal-related monitoring involves several monitoring judgments before and after task completion.

Accurate goal-related monitoring depends on students' metacognitive skills. Metacognitive skills develop during childhood and adolescence (Roebers, 2017). Therefore, primary and early secondary students may still have difficulty setting achievable goals and monitoring their performance accurately. For example, even late elementary school children often overestimate their performance (Finn & Metcalfe, 2014; Lipko, Dunlosky, Hartwig, et al., 2009). In the school context, this is problematic because overestimating one's ability can lead to poorer study decisions and academic performance (Dunlosky & Rawson, 2012). Accurate performance monitoring requires learners to use information and experiences while working on the task to retrospectively judge their performance (Hacker & Bol, 2019). In contrast, setting goals that are consistent with one's actual performance, i.e., accurate goal calibration, is subject to greater uncertainty. Children's goals may also reflect, at least to some extent, "desired" performance (Serra & DeMarree, 2016). Children, in particular, often fail to distinguish between their desired and expected performance, known as wishful thinking (Schneider, 1998). Hence, setting goals that are consistent with future performance may be even more difficult for children than judging their performance after completing the task.

The development of metacognitive skills, such as goal-related monitoring, is also closely linked to the development of children's working memory. Working memory is defined as the limited capacity to simultaneously hold information in mind and mentally work with it (Diamond, 2013). Working memory gradually improves throughout childhood, with strong improvements between the ages of 5 and 10 (Roebers, 2017). Working memory varies across children and is a strong predictor of academic achievement (Spiegel et al., 2021). In the context of goal-related monitoring, working memory helps learners to hold information about the goal and task experiences in mind and to compare this information with actual task performance. Information about potential discrepancies between the goal and actual performance can then be used to revise the goal to be consistent with past performance. Thus, the process of monitoring one's goals and performance is thought to require working memory.

However, research on the role of working memory in goal-related monitoring is scarce. A literature review summarized previous research on the role of working memory in metacognitive skills in general (Roebers, 2017). The few studies that examined the relation between working memory and metacognitive skills in elementary school children found a small correlation (r around .20, e.g., Bryce et al., 2015; Roebers et al., 2012). In addition, one study examined the relation between working memory and performance monitoring accuracy in kindergarten children (van Loon & Roebers, 2020). Children with better working memory were more accurate in judging whether they had solved a particular task correctly. However, the relation between working memory and children's goal calibration, i.e. the ability to set goals that are consistent with future performance, has not yet been investigated. Thus, although theoretically plausible, research on the role of working memory in goal-related monitoring is scarce.

1.2. The role of feedback for goal-related monitoring and goal revision

Assuming that goal-related monitoring remains difficult for elementary students, how might it be supported? One promising way to support accurate goal-related monitoring is to provide students with feedback after the task. However, the effectiveness of feedback seems to depend on the design of the feedback. For example, when students received feedback only on their task performance, the feedback did not consistently promote more accurate performance monitoring (e.g., Lipko, Dunlosky, Hartwig, et al., 2009; Miller & Geraci, 2011) or only for some students (e.g., only for high achievers in Hacker et al., 2000). More recently, feedback that additionally shows learners their self-evaluated performance estimates has been proposed as a particularly helpful way to improve performance monitoring (Urban & Urban, 2021; van Loon & Roebers, 2020). For example, learners are shown their actual performance and also their estimated performance, which they judged after they had completed the task. This type of feedback allows for a direct comparison of one's estimated and actual performance and has been shown to improve children's performance monitoring accuracy (Urban & Urban, 2021; van Loon & Roebers, 2020). These findings suggest that providing feedback on estimated and actual performance improves children's performance monitoring accuracy.

What remains unclear is whether feedback can also improve the accuracy of children's goal calibration. For example, feedback could include information about children's goal and their actual performance. Ideally, this type of feedback could help children become more accurate in their goal calibration. That is, the difference between their goal and actual performance should become smaller over time. However, in previous studies, feedback has focused on improving children's performance monitoring accuracy by providing information about whether retrospective performance estimates are consistent with actual performance (Urban & Urban, 2021; van Loon & Roebers, 2020). Thus, it remains unclear whether feedback that includes information about children's performance relative to their goal could also help children set goals that match their actual performance.

Two related and also unanswered questions are how children revise their goals and whether feedback could support goal revision. Regarding the first question, previous studies have shown that adults typically raise their goals after goal success and lower them after goal failure (e.g., Ilies & Judge, 2005; Theobald et al., 2021). A recent meta-analysis has shown that adult learners revise their goals based on the discrepancy between their initial goal and their actual performance (Theobald et al., 2025). For example, the more students' performance exceeded their goal (goal success), the more they subsequently raised their goal. The more students' performance fell below their goal (goal failure), the more they subsequently lowered their goal. Thus, ideally, learners should collect information about their goals and their performance in order to make appropriate control decisions, such as revising their future goals (Nelson

& Narens, 1990). However, goal revision has not been studied in children. Therefore, it remains an open question whether children would revise their goals when they monitor discrepancies between their goals and their performance.

Regarding the second question, previous research has not examined the role of feedback in adaptive goal revision. The recent meta-analysis revealed that previous research has not systematically tested whether feedback (vs. no feedback) affects goal revision (Theobald et al., 2025). In almost all studies, students received feedback. However, the type of feedback moderated goal revision. When students received feedback on goals and performance (vs. performance only), they raised their goals more adaptively: Students raised their goals more after success and lowered them more after failure. This finding suggests that students benefit from having information not only about their performance but also about their initial goals. Feedback on goals and performance may facilitate the assessment of goal-performance discrepancies, which supports adaptive goal revision.

1.3. The present study

Accurate goal-related monitoring and adaptive goal revision are key to successful SRL. However, the determinants of accurate goal-related monitoring and goal revision remain poorly understood. In primary and early secondary school, children's metacognitive skills and working memory are still developing. As a result, they may have particular difficulty accurately monitoring their goals and performance and revising their goals accordingly. Therefore, our first research question concerns how accurately eight-to eleven-year-old children monitor their goals and performance. Additionally, we examine whether they revise their goals based on their goal-related monitoring. Thereby, we also examine whether individual differences in working memory predict interindividual differences in goal-related monitoring accuracy. Our second research question is whether feedback on goals and performance can (1) improve the accuracy of children's goal calibration and performance monitoring and (2) support adaptive goal revision.

To answer these questions, we report results of a pre-registered study that included an experimental manipulation of feedback provision. Eight-to eleven-year-old children participated in a series of 6 quiz blocks. Before each block, they set a goal for how many questions they wanted to answer correctly. After each block, children reported how many questions they thought they had answered correctly. In the feedback condition, children received feedback on their performance relative to their self-set goal. Children in the no feedback condition received no feedback. Children were then given the opportunity to revise their goal for the next block. We tested the following pre-registered hypotheses.

H1. Feedback should improve goal-related monitoring. That is, the discrepancy between (1) goal and actual performance and (2) retrospective performance estimate and actual performance should become smaller over the course of the experiment in the feedback condition than in the no feedback condition.

H2. Better working memory is related to (1) a smaller discrepancy between the goal and the actual performance, and (2) a smaller discrepancy between the retrospective performance estimate and the actual performance.

H3. Goal-related monitoring should predict goal revision. Children should raise their goals when performance exceeded the goal (goal success), and they should lower their goals when performance fell short of the goal (goal failure). Thereby, larger goal-performance discrepancies should predict stronger goal revision.

H4. Feedback should promote adaptive goal revision. Children in the feedback condition should raise their goals more after goal success and lower them more after goal failure compared to children in the no feedback condition.

In addition, we examined whether feedback moderates the link between working memory and goal-related monitoring. Providing feedback on goals and actual performance, as was done in this study, may be one way to reduce working memory demands. Children do not have to remember their goal, nor do they have to estimate how many items they solved correctly. This may free up working memory capacity to monitor their goals and performance.

2. Methods

In the present study, children participated in a series of 6 quiz blocks (see 2.2.). We recorded their goals as well as their estimated and actual performance for each block to assess their goal-related monitoring and goal revision (see 2.3.1). Working memory was assessed after the experiment (see 2.3.2). In addition, the experiment included a between-subjects manipulation of feedback provision (see 2.2.). This manipulation was designed to test the role of feedback in children's goal-related monitoring and goal revision.

2.1. Participants

We tested 112 eight-to eleven-year-old children. We excluded two children who withdrew and four children whose data was lost due to technical problems. The final sample consisted of 106 children randomly assigned to either the feedback (n = 54) or no feedback (n = 52) condition (M_{Age} = 10.38, SD_{Age} = .88; 51% female). Sample size was determined based on pilot results. We used an online multilevel power analysis application (https://koumurayama.shinyapps.io/summary_statistics_based_power/) with the following settings and parameters: standardized t-value = 2.15, α = .05, β = .90, n = 48. The children and their parents gave their informed consent before the experiment. The children received a small gift for their participation, which was shown to them beforehand. Children were assured that they would receive the gift regardless of their performance on the task and that they would receive the gift even if they decided to stop participating. Ethical approval was obtained from the ethics committee of DIPF | Leibniz Institute for Research and Information in Education.

2.2. Procedure

Children were recruited by student assistants at a large natural science museum in Germany. The children were told that the experiment was about goal setting. We manipulated between subjects whether or not feedback was provided. Children in the feedback condition received feedback on their goals and actual performance on the quiz questions after each block. Children in the no feedback condition received no feedback on their goals or performance.

The experiment consisted of 6 blocks and a practice block (see Fig. 1). The practice block was a shorter version of the actual blocks. The practice block was used to familiarize children with experimental procedures. For each block, children were first asked to set a goal. Children also reported how confident they were that they could achieve the goal (self-efficacy) and the perceived importance of the goal (goal value) (not reported in this paper). The children then completed a multiple-choice quiz (maximum of 15 questions, only one correct answer) in a limited time window of 2 min. The time limit was set to make the task challenging for children and to ensure that children did not always achieve their goals. Children were not reminded of the time during a block to avoid distracting them while they were doing the task. Quiz questions within a block were presented sequentially on the screen for ease of reading. When the time for working on the questions was up, children could answer the question that was currently on the screen and were then automatically directed to the next block. This was done to keep the time on task comparable across children. This procedure was explained to the children beforehand so that they were aware of the limited time available. The quiz questions were piloted to ensure a similar level of

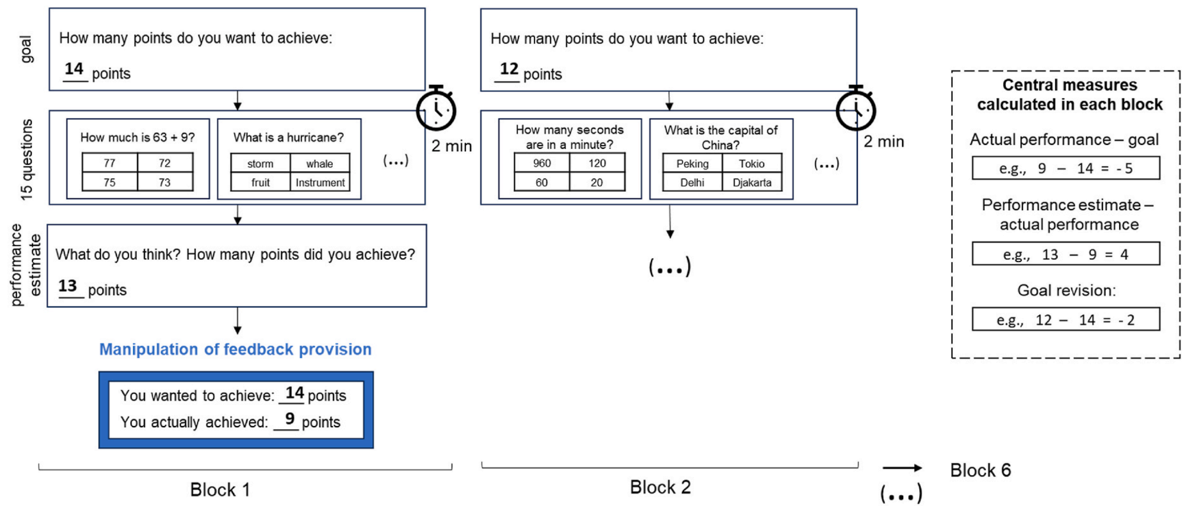

Fig. 1. Schematic Overview of the Experimental Procedure
Note. Before each block, children set a goal of how many points they wanted to achieve. They then answered up to 15 multiple-choice questions in a limited time window of 2 min. Afterwards, they were asked to indicate how many points they thought they had achieved. Finally, children in the feedback condition received feedback on their goals and actual performance. Children in the no feedback condition received no feedback. This procedure was repeated for a total of 6 blocks (see 2.2. for details on procedures). The central measures in the present study include the difference between children's goals, their performance estimates reported after each quiz task, and their actual performance for each block (see 2.3.1. for details). In addition, goal revision was operationalized as the difference between the goal in block t +1 minus the goal in block t (see 2.3.1.).

difficulty across blocks. After each block, children estimated how many questions they thought they had answered correctly. Children in the feedback condition were then told how many questions they had actually answered correctly. Finally, all children reported their achievement emotions (joy, pride, disappointment, anger, anxiety, boredom; not reported in this paper).

The main task was followed by a short numerical working memory task (adapted from Dirk & Schmiedek, 2016). Children had to memorize and update two one-digit numbers. In each of two horizontally placed cells, one initial digit (0–9) appeared simultaneously for 3000 ms. After an inter-stimulus-interval of 500 ms, a sequence of three updating operations was presented in the cells. The updating operations were additions and subtractions from −2 to +2. The total was never negative or above nine. The updating operations had to be applied to the memorized digits. The results also had to be memorized. The presentation time for updating operations was 2750 ms. The inter-stimulus-interval was 250 ms. At the end of each trial, the two end results had to be entered within a maximum of 20000 ms. The task includes 2 practice trials followed by 2 blocks of 5 trials each (10 trials in total).

2.3. Measures

2.3.1. Goals, retrospective performance estimates, and actual performance

The central measures for this study are children's goals, their retrospective performance estimates, and their actual performance (all measures range from 0 to 15). To assess goals, children indicated before each block how many points they wanted to achieve in that particular block. To assess retrospective performance estimates, children indicated after each block how many questions they thought they had answered correctly. Children's actual performance was assessed by summing the number of quiz questions answered correctly. Goals, retrospective performance estimates, and actual performance were used to obtain measures of children's goal-related monitoring and goal revision (see Fig. 1 for examples).

First, we calculated an indicator of children's goal calibration. To do so, we calculated the difference between children's goals and their actual performance (see, e.g., Theobald et al., 2021 for a similar operationalization). The smaller the absolute difference, the closer the goal was to actual performance. Positive values indicate that performance was above the goal, indicating goal success. Negative values indicate that performance was below the goal, indicating goal failure. Thus, this goal-performance discrepancy variable can also be used to quantify the severity of goal success or failure.

Second, we calculated an indicator of children's performance monitoring. To do so, we calculated the difference between children's retrospective performance estimates and their actual performance (see, e.g., Hacker & Bol, 2019 for an overview of studies with a similar operationalization). The smaller the absolute difference, the more accurately the children had monitored their performance. Positive values indicate that estimated performance was higher than actual performance, suggesting performance overestimation. Negative values indicate that estimated performance was lower than actual performance, suggesting performance underestimation.

Third, goal revision was operationalized as the difference between the goal in the following block (t +1) and the current goal (t) (see e.g., Theobald et al., 2021 for a similar operationalization).

2.3.2. Working memory

Working memory was operationalized as the total sum of correct responses across the two blocks. Each block contained 5 items with 2 numbers to update. Hence, the maximum sum score was 20.

2.4. Data analysis

All analyses were performed in R and significance levels were set at 0.05 for all analyses. The data and data analysis script are available through the Open Science Framework (https://osf.io/ynbr9/). Data analyses were preregistered (https://osf.io/82at7/). We estimated multilevel models to analyze the data (blocks clustered in participants). In this way, we used data from all experimental blocks, while accounting for the fact that we had repeated observations from participants. We also controlled for age as a covariate in all analyses (see Supplementary Tables 2–4), which did not alter the results reported below.

To test H1, we predicted goal-related monitoring by feedback (dummy coded; 1 = feedback, 0 = no feedback), experimental block, and the interaction between feedback and block. This allowed us to test (1) how goal-related monitoring developed over the course of experimental blocks (main effect of block), (2) whether goal-related monitoring differed between conditions across blocks (main effect of feedback), and (3) whether the development of goal-related monitoring differed by condition (interaction block x feedback). Recall that we operationalized goal-related monitoring once as the difference between goal and actual performance and once as the difference between retrospective performance estimate and actual performance. We estimated two separate multilevel models for each of the two goal-related monitoring indicators.

To test H2, we examined whether better working memory predicted a smaller average discrepancy between goal and actual performance across blocks. We also examined whether better working memory predicted a smaller average discrepancy between retrospective performance estimate and actual performance across blocks.

To test H3, we used the discrepancy between goal and actual performance in block t as a predictor of goal revision in the next block (t + 1).

To test H4, we predicted average goal revision across blocks by feedback, the difference between goal and actual performance, and the interaction between feedback and the difference between goal and actual performance.

For data analysis, we had to exclude 3 data points where children either did not set a goal ($k = 2$) or set a goal that was out of range ($k = 1$). This resulted in $k = 633$ data points that could be used for analysis. In addition, not all children participated in the working memory task that was administered after the main task. After the main task, the children were asked if they would like to participate in a small game (the working memory task) for a few more minutes. However, several children decided to withdraw at this point. A plausible reason for this dropout is the test setting. The children were tested during their visit to a science museum. Therefore, participation in the experiment took time away from visiting the museum with their families. Therefore, we used only a subset of 76 children for the working memory analyses ($k = 453$ data points). We decided not to impute these missing data because the entire variable (working memory) was missing for the participants. In this case, imputation relies heavily on assumptions about other participants' data (Enders, 2010). For example, the imputation model may assume that relations between variables are consistent across participants, which may not be the case. For example, our experimental manipulation induced systematic differences in goal-related monitoring and goal revision across participants, challenging this assumption. Therefore, we took a more cautious approach by using only the available data, while acknowledging the associated lower statistical power (see Limitations).

We tested whether children who decided to cancel participation after the main task differed from children who participated in the working memory task with respect to the central variables investigated in the present study. We did not find any systematic differences with respect to the difference between the goal and actual performance ($b = .002$, $SE = .62$, $p = .997$), the difference between estimated and actual performance ($b = -.12$, $SE = .52$, $p = .824$), goal revision ($b = -.34$, $SE = .19$, $p = .073$), age ($b = -.50$, $SE = .26$, $p = .051$), or experimental condition ($b = .70$, $SE = .44$, $p = .112$). These results suggest that the dropout did not systematically affect the results of the present study.

3. Results

3.1. Preliminary analyses: How accurate is Children's goal-related monitoring?

As a first step, we analyzed how accurately children monitored their goals and performance. A descriptive and correlation table is provided in the Supplementary Material (see Supplementary Table 1). First, we looked at the children's goal calibration. On average, children set a goal of 11 points per block ($M = 11.02$, $SD = 2.78$) and achieved an average of 10 points per block ($M = 10.04$, $SD = 2.55$). Consistent with this, the mean difference between goal and actual performance was negative ($M = -.91$, $SD = 2.84$, $d = .32$). Children in both conditions typically failed to achieve their goal (feedback condition: $M = -.69$, $SD = 2.21$, $d = .31$; no feedback condition: $M = -1.14$, $SD = 3.38$, $d = .34$, see also Section 3.2, Fig. 2A). That is, children set goals slightly above their actual performance, and more so in the no feedback condition. These results suggest that, on average, children show slightly inaccurate goal calibration, as their actual performance typically falls short of their goals.

Second, we found that children were rather accurate in their performance monitoring. On average, their retrospective performance estimates were only slightly higher than their actual performance ($M = .17$, $SD = 2.40$, $d = .07$). However, when looking at the two conditions separately, this finding was qualified: children in the no feedback condition on average overestimated their performance ($M = .79$, $SD = 2.79$, $d = .35$), whereas children in the feedback condition on average underestimated their performance ($M = -.43$, $SD = 1.80$, $d = .24$) (see also Section 3.2., Fig. 2B).

Overall, these discrepancies between goals, performance estimates, and actual performance suggest that children were already quite good at goal-related monitoring. Notably, however, the accuracy of children's goal-related monitoring varied between children (see 3.3.) and, importantly, between experimental conditions (see 3.2.). The two measures of goal-related monitoring were also strongly correlated at the within-subject level ($r = -.69$, $p < .001$). That is, children who set goals larger than their actual performance also typically failed to accurately judge their performance after completing the quiz block. Taken together, these results are consistent with previous research showing that children tend to overestimate their performance (Urban & Urban, 2021; van Loon & Roebers, 2020).

We also examined time trends in how goal-related monitoring accuracy developed over the course of the experiment. Children gained more and more experience with the task over the course of the experimental blocks. This means that children may recall task information from memory, such as information about their goals and performance in previous rounds. This memory may also contribute to the accuracy of their goal-related monitoring. We examined time trends for our two indicators of goal-related monitoring: goal calibration and performance monitoring. On average, children increasingly set goals that exceeded their actual performance over the course of the experiment (see Table 1). These results suggest that goal calibration became less accurate over time. Similarly, children's estimated performance increasingly exceeded their actual performance over the course of the experiment (see Table 1). These results suggest that performance monitoring became less accurate over time. Taken together, repeated task experience alone did not promote more accurate goal-related monitoring in either goal calibration or performance monitoring.

3.2. The role of feedback for goal-related monitoring

We then tested the hypothesis that children who received feedback on their goals and performance would become more accurate in their goal-related monitoring over the course of the experiment compared to children who did not receive feedback (H1). We also controlled for individual differences in working memory when predicting (the development of) goal-related monitoring. Feedback remained a significant moderator of the development of goal-related monitoring (see Supplementary Table 5).

First, we found an interaction between feedback condition and experimental block on the difference between the goal and actual performance (see Table 1, standardized ß = .11). As shown in Fig. 2A, the difference between children's goal and actual performance approached zero over the course of the experimental blocks in the feedback condition. That is, children's goal calibration became more accurate over time as the goal more closely matched their actual performance. Children in the no feedback condition did not show this improvement; in fact, over time, they tended to set goals that were higher than their actual level of performance. Taken together, these results suggest that feedback informing children of the discrepancy between their goal and actual

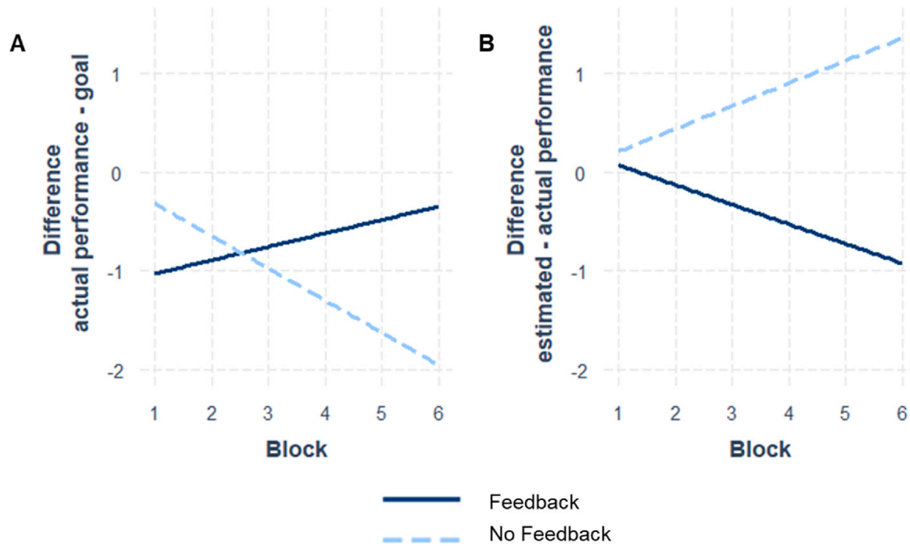

Fig. 2. Development of the Average Discrepancy between (A) Actual Performance and Goals and (B) Estimated and Actual Performance over the Course of the Blocks by Experimental Condition

Note. (A) In the feedback condition (dark blue, solid line), the difference between children's goals and their actual performance approached zero over the course of the blocks. Children's goals became more aligned with their actual performance over time. In the no feedback condition (light blue, dashed line), the difference between children's goals and their actual performance became more negative over the course of the blocks. That is, children fell short of their goals even more over time. (B) Children in the feedback condition tended to underestimate their performance more over the course of the blocks (estimated performance below actual performance). Children in the no feedback condition tended to overestimate their performance more over the course of the blocks (estimated performance above actual performance). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Feedback as a predictor of goal-related monitoring across blocks.

	Difference actual performance - goal			Difference estimated - actual performance		
Predictors	Estimates	CI	*p*	Estimates	CI	*p*
(Intercept)	0.01	−0.95 – 0.96	0.991	−0.02	−0.86 – 0.82	0.963
Feedback	−1.17	−2.51 – 0.17	0.086	0.29	−0.89 – 1.46	0.633
Block	−0.33	−0.49–−0.17	**<0.001**	0.23	0.07–0.39	**0.004**
Feedback x Block	0.46	0.24–0.69	**<0.001**	−0.43	−0.65–−0.21	**<0.001**
Random Effects						
σ^2	5.97			5.73		
τ_{00}	7.10 $_{id}$			4.50 $_{id}$		
ICC	0.54			0.44		
N	106 $_{id}$			106 $_{id}$		
Observations	633			633		

performance led to more accurate goal calibration.

Second, we found an interaction between feedback condition and experimental block on the difference between the estimated and actual performance (see Table 1, standardized ß = −.11). As shown in Fig. 2B, the difference between children's estimated and actual performance became more negative over the course of the experimental blocks in the feedback condition. This result suggests that children in the feedback condition underestimated their performance more over time. In contrast, children in the no feedback condition tended to overestimate their performance more over time. Thus, in both conditions, children's performance monitoring accuracy decreased over the course of the blocks, but in opposite directions: Children in the feedback condition underestimated their performance more over time, whereas children in the no feedback condition overestimated their performance more over time.

3.3. The role of working memory for goal-related monitoring

We then tested the hypothesis that better working memory predicts more accurate goal-related monitoring (H2). Consistent with our hypothesis, better working memory was associated with a smaller average discrepancy between goal and actual performance across blocks (b = .20, standardized ß = .24, SE = .07, p = .007; see Fig. 3A). Hence, those children who performed better on the working memory task also set goals that were better aligned with their actual performance. Similar results to those found for goal calibration were also found for the relation between working memory and performance monitoring. Better working memory was associated with a smaller average discrepancy between retrospectively estimated and actual performance across blocks (b = −.18, standardized ß = −.26, SE = .06, p = .002; see Fig. 3B). Children with better working memory were more likely to estimate their performance correctly after the task. Taken together, these findings suggest that children with better working memory are more accurate in goal calibration and performance monitoring.

3.4. The role of goal-related monitoring for goal revision across experimental conditions

Both goal-related monitoring measures were correlated with goal revision at the within-subject level (correlation goal revision with difference actual performance - goal: r = .57, p < .001; correlation goal revision with difference estimated - actual performance r = −.20, p <

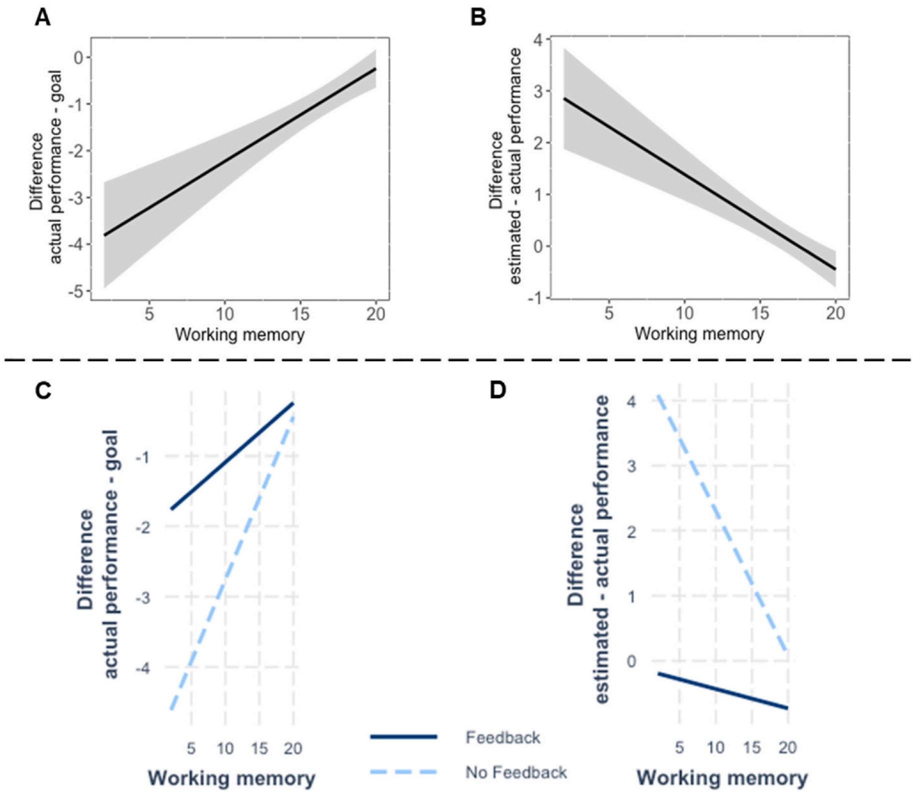

Fig. 3. Relation Between Working Memory and Goal-Related Monitoring
Note. Top panel: (A) Better working memory was associated with a smaller difference between goal and actual performance. (B) Better working memory was associated with a smaller difference between estimated and actual performance. Bottom panel: Relation between working memory and goal-related monitoring divided by feedback condition. (C) Relation between working memory and the difference between goal and actual performance. (D) Relation between working memory and the difference between estimated and actual performance. The interaction effects were not statistically significant.

.001). Thus, these results provide preliminary support for the hypothesis that children's goal-related monitoring is associated with subsequent goal revision.

First, we tested whether the discrepancy between goal and performance predicted goal revision. Across experimental conditions, we found that the more children's performance exceeded their goal, the more children subsequently raised their goal ($b = .44$, standardized ß = .34, $SE = .05$, $p < .001$). The more children's performance fell below their goal, the more they subsequently lowered their goal ($b = -.26$, standardized ß = −.31, $SE = .03$, $p < .001$, see Fig. 4A). Consistent with H3, children increased their goals the more they exceeded their goal; Children decreased their goals the more they failed their goal. This relation did not vary across task blocks. Hence, repeated task experience did not moderate the way goals are revised (see Supplementary Table 6). Thus, children use information about the discrepancy between their goals and actual performance to revise their goals accordingly.

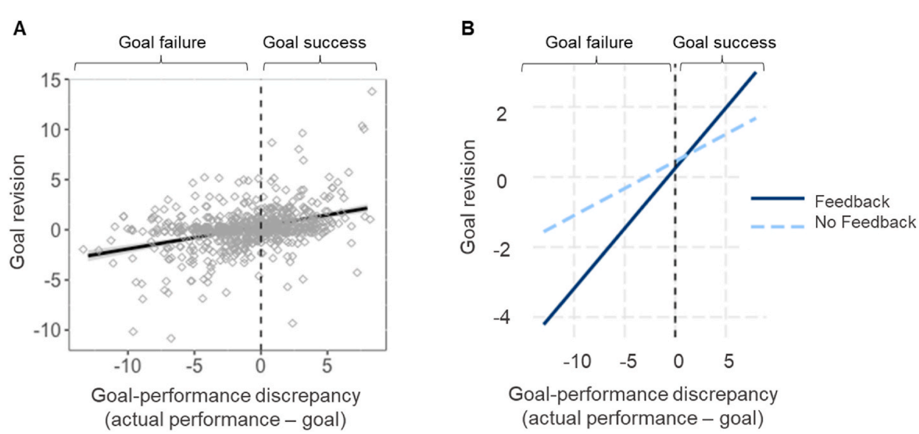

Fig. 4. Goal Revision after Goal Success and Goal Failure
Note. (**A**) Across conditions, the more children exceeded their goal (positive goal-performance discrepancy, x-axis), the more they subsequently raised their goal (y-axis). The more children missed their goal (negative goal-performance discrepancy), the more they subsequently lowered their goal. (**B**) The overall tendency to raise goals after success and to lower goals after goal failure was more pronounced in the feedback condition (dark blue, solid line) than in the no feedback condition (light blue, dashed line). Children in the feedback condition raised their goals more after goal success and lowered them more after goal failure than children in the no feedback condition. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Second, we tested whether the discrepancy between estimated and actual performance predicted goal revision. For example, children who realize that they have overestimated their performance may also become more conservative in their goal setting, since goals reflect (at least to some extent) one's expected performance on a task. However, because we did not preregister this hypothesis, the analysis is exploratory. We found that the difference between expected and actual performance predicted goal revision beyond the goal-performance discrepancy (b = .24, standardized ß = .37, SE = .03, p < .001). More specifically, we found that the more children overestimated their performance (performance judgement > actual performance), the more they subsequently lowered their goal (b = −.12, standardized ß = −.12, SE = .04, p = .002). The more children underestimated their performance (performance judgement < actual performance), the more they subsequently raised their goal (b = .11, standardized ß = .09, SE = .05, p = .032). This relation did not vary across task blocks. Repeated task experience did not moderate the way goals are revised (see Supplementary Table 7). Taken together, when children overestimated their performance, they subsequently lowered their goals and when they underestimated their performance, they subsequently raised their goals.

3.5. The role of feedback and the difference between goals and performance for adaptive goal revision

Based on our fourth hypothesis, we next tested whether feedback would promote adaptive goal revision. That is, we tested whether the general tendency to raise goals after success and lower them after failure reported above (see 3.4.) differed across conditions. We found an interaction of feedback condition and goal-performance discrepancy on goal revision (standardized ß = .16, see Table 2 & Fig. 4, part B). Consistent with our hypothesis, the relation between goal-performance discrepancy and goal revision was stronger in the feedback condition than in the no feedback condition. In the feedback condition, children raised their goals more strongly after goal success and lowered their goals more strongly after goal failure than children in the no feedback condition. Hence, feedback on goals and performance appeared to increase the general tendency to raise goals after success and lower goals after failure.

3.6. Does working memory moderate feedback effects in goal-related monitoring?

In a final, not pre-registered analysis, we examined whether feedback moderated the association between working memory and goal-related monitoring. The association between working memory and goal-related monitoring (as reported above) appeared to be attenuated when feedback was provided (see Fig. 3, lower parts C and D). In other words, when feedback was provided, children with lower working memory showed goal-related monitoring accuracy similar to that of children with better working memory. Therefore, we tested whether feedback would moderate the relation between working memory and goal-related monitoring. We tested the interaction between feedback and working memory once as a predictor of the difference between goal and actual performance and once as a predictor of the difference between estimated and actual performance. However, the interaction effects were not statistically significant for either the difference between goal and actual performance (b = −.15, standardized ß = −.09, SE = .17, p = .367) or the difference between estimated and actual performance (b = .19, standardized ß = .13, SE = .13, p = .137). These results suggest that feedback did not moderate the relation between working memory and goal-related monitoring. The sample size for the working memory analyses was comparatively smaller (including data from n = 76 of 106). A simulation analysis showed that the observed power was at best 37%, which means that the statistical power to detect the interaction effect was low.

4. Discussion

The aim of the study was to investigate the role of feedback and working memory for goal-related monitoring and adaptive goal revision in 8–11-year-old children. The results supported our pre-registered hypotheses. Regarding goal-related monitoring, we found that, on average, children set goals slightly above their actual performance and overestimated their task performance. However, children who received feedback on their goals and actual performance became more accurate in their goal-related monitoring over the course of the experiment compared to children who did not receive feedback. In addition, children who performed better on the working memory task were also better at monitoring their goals and performance accurately. Goal-related monitoring, in turn, predicted how goals were revised. Specifically, we found that, on average, children raised their goals when their performance exceeded the goal. Children lowered their goals when their performance fell short of the goal. This regulatory tendency was more pronounced in the condition where children received feedback on their goals and performance than in the no feedback condition. In other words, with feedback, children who identified discrepancies between goal and actual performance revised their goals more adaptively. In summary, this study highlights the strong link between goal-related monitoring and adaptive goal revision. Thus, elementary school children use goal-related monitoring to adaptively regulate their goals, especially when they receive additional support through feedback.

Consistent with previous findings, children, on average, tended to set overly optimistic goals. Children set goals that were slightly above their current level of performance, suggesting inaccurate goal calibration at a small to moderate level (d = .32). Setting ambitious goals is not inherently negative, as it can mobilize effort and promote performance (Bandura, 1991; Locke & Latham, 2013). However, even small but consistent discrepancies between goals and performance are relevant because they can undermine student motivation in the long run. For example, unrealistically high goals can lead to repeated experiences of goal failure. Repeated goal failure has been shown to undermine students' self-efficacy and intrinsic motivation (Theobald et al., 2023).

Table 2
Difference between performance and goal and feedback as predictors of goal revision.

	Model 1			Model 2		
Predictors	Estimates	CI	p	Estimates	CI	p
(Intercept)	0.35	0.19–0.51	**<0.001**	0.45	0.22–0.67	**<0.001**
Difference actual performance - goal	0.22	0.18–0.27	**<0.001**	0.15	0.10–0.21	**<0.001**
Feedback				−0.18	−0.50 – 0.13	0.252
Feedback x Difference actual performance - goal				0.18	0.10–0.27	**<0.001**
Random Effects						
σ^2	3.89			3.77		
τ_{00}	0.00_{id}			0.00_{id}		
N	106_{id}			106_{id}		
Observations	633			633		

Taken together, persistent inaccurate goal calibration, even at moderate levels, is practically critical because it can affect children's motivation to work on a task.

Similarly, it is important for learners to be able to monitor their performance accurately. According to metacognitive theories (Nelson & Narens, 1990), accurate goal-related monitoring is necessary to engage in monitoring-based control, i.e., to adjust strategies, manage one's efforts, or revise one's goals. Therefore, if learners' goal calibration and performance monitoring is inaccurate, it may also lead to poor control decisions (Bayard et al., 2021) and lower academic performance (Dunlosky & Rawson, 2012). Applied to the present study, even small discrepancies between one's estimated and actual performance have practically relevant consequences. Children who overestimate their performance assume that they have answered more quiz questions correctly than they actually have. These students may decide not to review the material or to check whether their answers are really correct. Thus, overconfidence can lead to poor study decisions and lower academic performance.

Critically, repeated task experience alone did not help children improve their goal-related monitoring. This result is in line with the findings of previous studies (Finn & Metcalfe, 2014; Lipko, Dunlosky, Hartwig, et al., 2009). In the present study, children who did not receive feedback on their goals and performance even became increasingly inaccurate in their goal monitoring. Given this trend, even small to moderate deviations in children's goal monitoring become practically relevant. For example, in the present study, children's goal and performance estimates deviated moderately from their actual performance (Cohen's *d* around .30). However, in the absence of feedback, this moderate inaccuracy is likely to increase (or at least persist) over time. As mentioned earlier, children who persistently set overly optimistic goals and overestimate their performance run the risk of losing motivation and making inappropriate study choices. Therefore, it is important to better understand which children need additional support and how to promote accurate goal-related monitoring.

Regarding the question of who needs additional support in goal-related monitoring, our results clearly show that individual differences in children's working memory play a role. We found that children who performed poorly on the working memory task were also more likely to be inaccurate in their goal-related monitoring. For example, children who scored one standard deviation below average on the working memory task overestimated their performance by about 2 points. In contrast, children who scored one standard deviation above average on the working memory task hardly overestimated their performance at all. This example illustrates the practical importance of this relation. In addition, our results highlight the close link between working memory and metacognitive skills.

Theoretically, working memory may be required for the application of metacognitive skills such as goal-related monitoring. For example, accurate goal calibration requires learners to set goals that are consistent with future performance. Performance monitoring requires learners to accurately estimate how they performed on a task. Thus, accurate goal-related monitoring requires learners to hold in mind information about their goals, their typical performance on a task, or their experiences while performing the task, which strains working memory (Roebers, 2017). Working memory also supports other processes relevant to accurate goal-related monitoring. For example, working memory is important for updating information or inhibiting task-irrelevant information (Diamond, 2013). As working memory gradually improves throughout childhood (Roebers, 2017), elementary and early secondary school children may need additional support to monitor their goals and performance accurately.

When considering how to improve the accuracy of children's goal-related monitoring, feedback is a simple and promising method. In the present study, goal and performance feedback led to more accurate goal calibration and performance monitoring than no feedback. In the feedback condition, children's self-set goals increasingly approached their actual performance levels, suggesting better goal calibration. This is particularly impressive given that children's goals are often unrealistically high due to wishful thinking (Schneider, 1998; Serra & DeMarree, 2016). Feedback effects were small to moderate in magnitude, but of high practical importance. Feedback on goals and performance is easy to implement. Moreover, feedback gradually increased children's goal-related monitoring. Thus, providing feedback is an easy-to-implement intervention whose effects may even increase over time.

The present findings also add to those of previous studies showing the positive effects of feedback on performance monitoring in younger age groups (Urban & Urban, 2021; van Loon & Roebers, 2020). However, these previous studies have not tested whether feedback helps children improve their goal calibration. The present study fills this gap by showing that feedback on goals and performance can help children set attainable goals that are appropriate for their level of performance.

In addition, we found that children's performance monitoring became more inaccurate over time in both conditions, but in opposite directions. Children in the feedback condition were more likely to underestimate their performance over the course of the experiment. In contrast, children in the no feedback condition were more likely to overestimate their performance. One explanation for the underestimation of performance in the feedback condition is that children may have strategically kept their performance expectations low. Low expectations may increase the likelihood that actual performance will be higher than expected, which could elicit positive emotions such as relief (Pekrun et al., 2002). Thus, children may strategically underestimate their performance to be positively surprised by their actual higher performance.

One explanation for the overestimation of performance in the no feedback condition is that children used misleading cues to judge their performance. Since children did not receive corrective feedback about their actual performance, they had to base their judgments on cues that they thought were informative about their performance (de Bruin & van Merriënboer, 2017). Such cues could be the familiarity of the task or the ease with which the task is performed. For example, as children became more familiar with the task, they became faster at pressing the correct keys on the keyboard or reading the task instructions. However, task familiarity or ease of processing is not diagnostic of actual performance on the task, leading children to overestimate their performance. Hence, these examples illustrate that memory for task experience can sometimes even be misleading when children begin to rely on non-diagnostic cues to judge their performance. However, since we did not ask children how they arrived at their retrospective performance estimate, these explanations are only hypothetical and warrant further research.

Regarding goal revision, we found that children use their goal-related monitoring to revise their goals. Consistent with findings in adult samples (Ilies & Judge, 2005; Theobald et al., 2021), children raised their goal the more their performance exceeded their goal and lowered their goal the more their performance was below their goal. In addition, children raised their goal more when they underestimated their performance and lowered it more when they overestimated their performance. The magnitude of this relation was somewhat smaller compared to the relation between goal-performance discrepancy and goal revision. Goal-performance discrepancy may be more informative for goal revision because it directly contrasts one's performance with respect to the goal.

These findings also support SRL models (Zimmerman, 2000) and metacognitive theories (Nelson & Narens, 1990). These theories suggest that learners use goal calibration to adjust their future learning, in this case their goals. The general regulatory tendency to raise goals after success and lower them after failure further supports social cognitive theory (Bandura, 1991). Goal success is thought to increase children's belief in their ability to achieve the current or higher goal level next time, thereby supporting upward goal revision. In contrast, goal failure is hypothesized to decrease children's belief in their ability to achieve the current goal level, thereby promoting downward goal revision. Thus, based on social cognitive theory, upward goal revision after goal success and downward goal revision after goal failure constitute adaptive goal revision mechanisms. In summary, consistent with self-regulated learning theories and previous empirical findings with adults, we found that children generally raise their goals after goal success and lower their goals after goal failure.

In addition, the present study showed that feedback on goals and actual performance is a highly effective way to support adaptive goal revision. The adaptive goal revision mechanism of raising goals after success and lowering goals after failure was particularly pronounced when children received goal and performance feedback. This finding is consistent with recent meta-analytic evidence highlighting the effectiveness of goal and performance feedback (vs. performance only) for adaptive goal revision (Theobald et al., 2025). Raising goals after success and lowering them after failure is important for learners to ensure that they pursue goals that are neither too difficult nor too easy. For example, goal failure due to unrealistically high goals can have negative consequences for students' motivation (Theobald et al., 2023). Without explicit feedback on their goals and performance, students may consistently set goals that are too high. Therefore, providing feedback on goals and performance is an effective way to help students avoid overestimating themselves and to set achievable goals.

4.1. Limitations and future directions

The present study has several limitations that provide directions for future research. First, the laboratory setting provided a high degree of control over task procedures and feedback. However, tasks and performance feedback may differ in several ways in a real school setting. For example, writing a real exam is more personally relevant to students. In addition, students often receive feedback only on their performance (not on their goals). Performance feedback, such as feedback on exam grades, is also provided with greater delays and has more serious consequences for students. Thus, the personal relevance of the task, as well as the content, importance, and timing of the feedback, may influence goal-related monitoring and goal revision. Future studies should test whether the present results generalize to real classroom settings. For example, in the classroom, goal success or failure could be operationalized as the difference between the grade goal and the actual grade across multiple school exams. In addition, one could manipulate the timing of feedback or whether feedback includes information about performance and goals or performance only. This would allow testing whether children become more realistic in predicting their school grades across exams, and whether this effect depends on different feedback characteristics.

Second, we focused on a limited age range of 8- to 11-year-old children. At this age, children are able to evaluate their own performance and adapt strategies, but still show high variability in metacognitive abilities (Roebers, 2017). Future studies should test whether the findings are replicated in younger or older samples.

Third, future studies should continue to test the role of working memory for goal-related monitoring and goal revision. In particular, we encourage research on the question whether children with lower working memory may especially benefit from metacognitive support, such as feedback on goals and performance. Unfortunately, due to participant dropout, the sample size was too low to test this interaction with sufficient power. Therefore, future studies need larger sample sizes to examine these individual differences. A larger sample size would also allow to test more complex interactions, such as whether feedback and working memory may together moderate the relation between goal-performance discrepancy and goal revision. Another fruitful avenue for future research is to consider potential mechanisms by which working memory might support goal-related monitoring and goal revision. Working memory could help students update information, inhibit task-irrelevant thoughts, or flexibly switch between strategies (Diamond, 2013). Therefore, future studies could collect data on other executive functions, such as inhibition and task switching.

Fourth, the children in this study were trained to improve their goal calibration, performance monitoring, and goal revision in a circumscribed learning task. It would therefore be important to test whether the feedback-induced improvements in goal-related monitoring and adaptive goal revision are maintained and transfer to other tasks. For example, future studies could combine the feedback intervention with more comprehensive, formal instruction in self-regulated learning strategies. For example, self-regulated learning training programs have been shown to improve students' use of metacognitive strategies, especially when the training program included feedback from a teacher (Theobald, 2021). Thus, the combination of feedback on SRL and formal strategy training bears the potential to further improve students' metacognitive skills.

4.2. Practical implications and conclusions

Goal revision in response to performance feedback is a highly important self-regulatory process. Accurately monitoring one's goal progress and setting achievable goals is important because it supports academic achievement and motivation (Theobald et al., 2023). Students are required to revise their goals adaptively in everyday school life. Still, it has been largely unclear how accurately they monitor their goals and performance, and whether they use their goal-related monitoring to revise their goals. Previous studies on goal revision have exclusively examined adult samples (Ilies & Judge, 2005; Theobald et al., 2021). Thus, the present study is the first to provide insight into how children dynamically monitor and revise their goals.

The results of the present study therefore have important practical implications. First, children with poorer working memory have particular difficulties in monitoring their goals and performance accurately. Thus, interventions aimed at improving goal-related monitoring should consider interindividual differences in working memory. Providing feedback, as was done in this study, may be one way to reduce working memory demands. We found a trend that children with lower working memory benefited more from feedback. However, this effect needs to be replicated with larger samples. Second, we found positive effects of feedback that provides children with information about their self-set goals and actual performance. Students who received feedback monitored their goals more accurately. Children used information about the discrepancy between their goals and performance to revise their goals. Consequently, accurate goal-related monitoring also supported more adaptive goal revision. As a result, children who received feedback became better at setting goals that matched their actual performance levels. Hence, feedback is an easy-to-implement and highly effective instructional method. Therefore, teachers should provide students with feedback on both their goals and their performance to support their monitoring and regulation processes.

CRediT authorship contribution statement

Maria Theobald: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Garvin Brod:** Writing – review & editing, Supervision.

Materials availability and statement of preregistration

The data and the analytic code necessary to reproduce the analyses and the study materials are publicly available at the following URL: https://osf.io/ynbr9/.

The analyses presented here were preregistered. The preregistration is publicly available at the following URL: https://osf.io/82at7/.

Deviations from the preregistration are reported in the manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.learninstruc.2025.102108.

Data availability

The data and data analysis script are available through the Open Science Framework (https://osf.io/ynbr9/).

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